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ABSTRACT

This book provides titles, author information, and abstracts of presented papers at the 1993 National Association of Research in Science Teaching Conference. The abstracts are divided into the following sections: (1) Alternative Assessment; (2) Approaches to Research; (3) Conceptual Change; (4) Gender and Equity; (5) History, Philosophy, and Epistemology; (6) International Sessions (English); (7) International Sessions (Spanish); (8) Invited Sessions; (9) Learning Science; (10) Policy and Reform; (11) Role of Language; (12) Science Teacher Education; (13) Teaching and Learning College Science; (14) Teachers as Researchers; (15) Teaching Science; and (16) Use of Technology. (PR)

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ABSTRACTS OF PRESENTED PAPERS

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The Florida State University

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ALTERNATIVE ASSESSMENT

1.02

ASSESSING PERFORMANCE IN SCIENCE IN SCOTTISH SCHOOLS: NATIONAL MONITORING OF PRACTICAL AND PROCESS SKILLS

Rae Stark, Jordanhill College, Glasgow, Scotland, U.K.

The Assessment of Achievement Program was set up by the government in the early 1980's to monitor standards in key curricular areas at significant stages in pupils' experiences in Scottish schools. A rolling program of surveys in English language, Mathematics and Science has been established. In the second survey of Science performance in 1990, nationally representative samples of pupils at 9, 12 and 14 years of age were assessed using a combination of pencil-and-paper and practical tasks. The emphasis has always been on doing science and the assessment techniques reflect an active participative view of school science. The assessment materials used were designed to provide information on performance levels within year groups, across year groups and by gender. Information from the program is disseminated by the government to all schools, colleges and other educational establishments in Scotland. The final and summary reports of the 1990 survey have been published. Dissemination materials for teachers are in production.

1.10

REFORMING CLASSROOM AND HIGH STAKES ASSESSMENT IN SCIENCE AND MATHEMATICS

James A. Shymansky, The University of Iowa

In the science and mathematics education communities, leaders seem to agree that instruction needs to focus more on understanding than coverage: Being able to think about and use ideas So solve problems is more important than being able to memorize and regurgitate isolated facts. Teachers and test makers both have been accused of doing too little to directly promote this kind of higher order learning and thinking. Each group points to the other as reason for not doing more. Our project represents an effort to refocus teaching and testing by working with both groups simultaneously. In the symposium we will describe our

1.10 SHYMANSKY CONTINUED

work with ninth grade science and math teachers and architects of the Iowa Test of Educational Development to develop classroom assessment strategies and outcome measures of higher order learning and thinking.

5.05

EXTERNAL EXAMINATION AND THE SCIENCE CURRICULUM: DO THEY MONITOR OR CONTROL?

Marvin Wideen, Tom O'Shea, Simon Fraser University, and
George Ivany, University of Saskatchewan

This study examined the impact of large scale/high risk testing introduced at the grade 12 level on the classroom practice of 84 science teachers in grades 7, 10 and 12 in the province of British Columbia. Classroom teaching was observed and teachers interviewed about their practice along with district officials and principals. The data showed that the impact of final grade 12 examinations was being felt both within and beyond the classroom. At the classroom level, the results point to a pattern of science teaching that narrowed the instructional pattern as we moved from grade eight to grade twelve which the research team attributed to final high risk examinations. Teacher interviews supported these findings as it was found that at the grades 8 and 10 levels, teachers generally reported little influence coming from the examinations. However, when the remarks from grade 12 teachers were examined, they reported that the exams had an enormous impact on their teaching. The study has implications both for curriculum decision making and for educational reform.

5.05

PROBLEM SOLVING SKILLS PERFORMED BY TAIWANESE STUDENTS IN INTERNATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS PERFORMANCE TEST

Jong-Hsiang Yang, National Taiwan Normal University

International Assessment of Educational Progress (IAEP) data were used to examine the nature and practice of science teaching in Taiwan. Science teaching in Taiwan has suffered because of severe competition created by entrance examination for further schooling for some

5.05 YANG CONTINUED

decades. The focus of this study was on problem solving skills achieved in the IAEP performance test. A follow up study, including both structured and unstructured interviews, was also conducted to investigate the strategies adopted by participating students. The results were also compared to a similar study conducted by Semple (1992) in Scotland to study the different strategies used in problem solving in students of two different cultures. The materials followed correlational analysis and ANOVA.

5.06

EFFECT OF HYPERCARD AND TRADITIONAL PERFORMANCE ASSESSMENT METHODS ON EXPERT-NOVICE CHEMISTRY PROBLEM SOLVING

David D. Kumar, Arthur L. White, and Stanley L. Helgeson, National Center for Science Teaching and Learning

This study investigated HyperCard™ as a tool for assessment in science education and determined if a HyperCard™ assessment instrument could differentiate between Expert and Novice student performance in balancing stoichiometric equations. Five chemical equations of increasing difficulty were presented by traditional Pen-Paper and by a HyperCard™ (Hyperequation) program. Thirty advanced-level (expert) and 30 regular-level (novice) chemistry students were randomly assigned to HyperCard™ and traditional pen-paper groups of 15 each. Scoring was based on five dependent variables: Ranked scores, number of attempts, rate of attempts, time on task, and correctness. Overall correlations indicated that students with high ranked scores correctly balanced more equations, required fewer attempts, and required less time per attempt than did students with low ranked scores. MANOVA results showed that ranked scores and correctness scores for both Experts and Novices P were significantly higher on HyperCard™ compared to pen-paper assessment; the Novice scores on HyperCard™ nearly equaled the expert pen-paper assessment scores. Novices attended to tasks longer and got more correct while experts required less time for success. The results suggest that HyperCard™ can be used for assessment in science education and for differentiation between expert and novice student performance.

5.06

ASSESSING COLLEGE STUDENT PROGRAMMING ABILITIES

Angel Syang and Lowell J. Bethel, The University of Texas at Austin

Computerized Adaptive Testing (CAT) is a testing procedure that adapts an examination to a student's ability by administering only questions of appropriate difficulty for the student. During the last decade, Item Response Theory (IRT) has offered new approaches for estimating a student's ability and for selecting questions. In general, IRT based CAT systems can provide more accurate ability estimation with fewer questions than traditional paper-and-pencil tests. In this study, we present a testlet design which groups questions into related units rather than considering each question as an independent item. The study has shown that a Computerized Adaptive Test using Item Response Theory can be successfully implemented in Computer Science and our testlet format is a better way to assess college student programming abilities.

6.06

NOVEL METHODS OF ASSESSING STUDENTS' UNDERSTANDINGS OF SCIENCE TECHNOLOGY AND SOCIETY (STS) ISSUES

Jim Gaskell and Renée Fountain, The University of British Columbia, and Reg Fleming, The University of Saskatchewan

This symposium will explore theoretical and practical issues in assessing Science Technology and Science (STS) topics. Given the growing importance of STS as a part of science curriculum and the importance of assessing all parts of the curriculum if they are to be taken seriously in the classroom by teachers, It is argued that a priority should be given to understanding students' ideas about science-based issues and ways of assessing them. An opportunity for exploring ways of assessing students' ideas about socioscientific issues arose in the context of the 1991 British Columbia Science Assessment. After presenting background information, sample controversies will be presented using print and video formats. These will be followed by a discussion of issues such as context dependency, presentation format, and response mode. Sample results showing differences by grade, gender, response mode and presentation format will be provided. Data have been collected from 5000 students and coded by a team of

6.06 GASKELL CONTINUED

teachers using an instrument developed for the purpose. Both qualitative and quantitative techniques were used for analysis of the data.

7.05

EVALUATION OF HIGH SCHOOL BIOLOGY LABORATORY MANUALS FOR SCIENCE PROCESS SKILLS AND HIGHER LEVEL THINKING

Stephanie Auls, South Carolina State University,
Paul Germann and Sandra Haskins, University of Missouri-Columbia

Laboratory manuals play a very important role in defining the goals and procedures for laboratory activities. Manuals should not only help students focus observations and develop explanations (Fuhrman, Lunetta, Novick, 1982), but also should promote scientific inquiry. While lab manuals may focus on providing directions for laboratory performance of an activity, there could be diversity in how they treat background information, science process skills, analysis and interpretation, further investigation and application of knowledge and skills found in the lab. The purpose of this study included comparing eight biology laboratory manuals to determine if the manuals allow students the opportunity to inquire, investigate, and find out information on their own. After developing a checklist and operational definitions two researchers independently scored each manual, checked for agreement, and negotiated differences. Most manuals took deductive, experimental, and descriptive approaches to lab activities. While a majority of manuals did ask questions at all levels of Bloom's taxonomy of intellectual ability, science process skills were not generally addressed. Implications of these results are discussed.

7.05

AN ASSESSMENT STRATEGY USING STUDENT-GENERATED KNOWLEDGE REPRESENTATIONS

Joseph Faletti, Kathleen M. Fisher, San Diego State University, and
Ellen D. Gagne, Catholic University

7.05 FALETTI CONTINUED

This paper describes an assessment strategy using student-generated knowledge representations. Several case studies will be shown to illustrate the advantages of such a strategy, including: Knowledge construction is generative; A semantic network allows the reviewer to see not only what concepts and relations a student chooses to include in describing a particular topic, but also reveals the higher order structure—the kinds and degrees of organization that are invoked; Semantic networks are exquisite tools for discovering students' alternative conceptions; Semantic network construction requires a relatively high level of precision; An indirect but very important potential effect of assessment via knowledge representation is that it promotes good thinking and learning habits; and Semantic network construction tests permit causally integrated diagnosis of learning problems. The primary disadvantage is that students must develop skill using the software prior to the assessment. As computers are integrated into classrooms more, this will become less problematic.

7.05

TWO-QUARTER EVALUATION OF LINKED COLLEGE BIOLOGY AND ENGLISH COURSES

Isaac H. Lassiter, Steve McCullagh, and Dan Fay, Georgia State University

This synthesis of two studies evaluated an interdisciplinary **tandem** sequence of courses in three areas: (a) meanings and values of the experiences for the participants; (b) students' understandings of scientific and literary forms of knowledge and ways of knowing, with emphasis on the extent to which these reflect a position of contextual relativism; and (c) students' perceptions of the relationship between the two tandem sets of courses. These studies were based upon a phenomenological and interpretive research paradigm and used principally qualitative data sources such as documents, classroom observations, interviews, and questionnaires. The assessment was based upon both predetermined and emergent categories. Predetermined categories included: (a) honoring one's own words and thoughts; (b) use of natural language through formal essays, informal in-class writing,

7.05 LASSITER CONTINUED

and reflective journal writing; and (c) contextual relativism as a complementary conceptualization of diverse academic disciplines. Emergent categories included social interactions, group activities, and attitudes. The implications of these findings are presented for three relevant contexts: (a) the tandem courses, (b) the curriculum of the college, and (c) interdisciplinary education.

8.05

SYMPOSIUM: PROGRAM EVALUATION

Ann C. Howe, University of Maryland at College Park,
Sarah Berenson, North Carolina State University,
Frances Lawrenz, University of Minnesota, and
John Falk, Science Learning, Inc.

New perspectives on program evaluation are emerging as the need for accountability becomes more urgent and evaluation models that once seemed adequate now seem simplistic. Private and public funding agencies at all levels are demanding that evaluation plans be comprehensive and realistic with a greater share of resources devoted to this aspect of a project than was formerly the case. Symposium presenters will use their experiences to illustrate and explore aspects of evaluation as follows: (1) Evaluation from the perspective of The National Science Foundation; (2) Evaluation of graduate and undergraduate courses in the biological sciences for the purpose of improving programs and promoting faculty development; (3) Evaluation in museums and other out-of-school settings where no single approach is possible and a range of non-intrusive methods are used to assess the impact of the museum experience ; and (4) Evaluation as participant-observation when the evaluator must abandon the traditional role of objective observer in order to understand the program's impact and meaning. The issues raised in the presentations will be the basis for posing a series of questions to the audience for reaction, interaction and discussion.

12.05

STUDENTS EVALUATING TEACHING: AN EFFECTIVE INSTRUMENT FOR TEACHER CHANGE

Haroldo G. Albuquerque, The Florida State University

This is a report of a study about the interactions between prospective student-teachers and their professor's ideas of an undergraduate science methods course at a large mid-western university. The main purposes of the study were: To identify students dissatisfactions about the structure of the course as a main input for change, and to analyze the consistencies and inconsistencies between teacher's and students' ideas about the strengths and weaknesses in the course. The structure of the science methods course emphasized three important stages: Preparation for microteaching, microteaching and analysis of microteaching. Two types of questionnaires constituted the instrument of this study: One type was designed for the prospective student teachers and another, for the professor of the science methods course. Students were surveyed after the microteaching because that activity gave them a better idea of how effective the course was for applying what they learned in the course. Vignettes of six students considered most and least satisfied with the course were constructed. The data sources for the study are the six vignettes, the professor' s responses and contributions from other students.

12.05

VALIDATION OF PERFORMANCE-PORTFOLIO ASSESSMENT IN AN INTEGRATED MATHEMATICS/SCIENCE ELEMENTARY METHODS COURSE

Gilbert L. Naizer, Texas A&M University

The purpose of this study is to evaluate the validity of using performance-portfolios in an elementary methods class. The performance-portfolios, designed to track and assess the authentic outcomes involved in solving the assigned teaching problems, consist of five sections containing products associated with each phase of the teaching process (i.e., planning, designing, executing, analyzing, reflection). In order to examine the validity of performance-portfolios, the students' domain-strategic and general-learning strategic knowledge will be assessed. These measures, along with prior pedagogical experience, will be used to predict group membership of students (earned grades of

12.05 NAIZER CONTINUED

A, **B**, etc.) as determined by performance portfolios. The contribution of each predictor variable, the percent of correct predictions, and the canonical discriminant functions will be examined. Another validation procedures will consist of an examination of the correlation between a group skills self-evaluation and the corresponding sections of the performance-portfolios. The correlation between the results of a traditional teacher-designed final exam and the students' scores on the performance-portfolios will also be examined.

12.15

PREDICTIVE VALIDITY OF THE GROUP ASSESSMENT OF LOGICAL THINKING TEST

Bill Baird and Phil McLarty, Auburn University, and
Eddie Shaw, University of South Alabama

The study examined the relationship between the Group Assessment of Logical Thinking (GALT) Test and scores in selected events of the Science Olympiad. The GALT is a pencil and paper version of the Piagetian interview, used to classify learners as concrete, transitional or formal. The GALT uses a double multiple-choice format to measure conservation, proportional reasoning, controlling variables, probabilistic reasoning, correlational reasoning, and combinatorial reasoning. Junior high students from sixteen schools were given the GALT before participating in the bioprocess laboratory, road rally, or science crime busters events at the National Science Olympiad during May 1992. These events were selected because they are described in the coach's manual as requiring the same skills as those assessed by the GALT. Analysis of GALT scores and Olympiad event scores indicate that up to 69 per cent of total variance in the bio-process lab can be explained by GALT scores. The GALT is not as effective at predicting success in the road rally or science crime busters events. This may be explained in part by the fact that individuals compete in the bio-process lab, while teams of two take part in the road rally and crime busters events.

12.15

A RUBRIC FOR ASSESSING MIDDLE SCHOOL STUDENTS EFFORTS AT DESIGNING EXPERIMENTS

Paul Germann, Roberta Aram, and Gerald Burke,
University of Missouri-Columbia

Research has contributed to a growing body of knowledge concerning basic and integrated science process skills, the kinds of learning promoted by laboratory manuals, student learning during laboratory activities, curricular strategies for the laboratory learning and instruction, and valid instruments to assess laboratory learning. Central to this study is the development and use of one section of the Science Process Skills Inventory (SPSI) that evaluates student efforts at writing experimental designs. The instrument guides teachers and researchers in assessing seven main components of experimental designs. Each component consists of elements unique to the specific laboratory exercise. Subsequent to its development, the instrument was used to score 364 student responses to the **design an experiment** portion of an authentic assessment instrument for science process skills. Non-parametric analyses were used to uncover relevant relationships within student responses. Results indicate that explicit, incremental development of the science process skills of formulating hypotheses and identifying variables, together with model examples, may be a means to facilitate student success in designing science experiments. Implications for the classroom and for research are discussed.

12.15

EVALUATION OF SCIENCE I: YEAR ONE-IMPLEMENTATION

Cynthia Ledbetter, UT-Dallas,
James Barufaldi, UT-Austin,
Robert James, Texas A&M, and
Steven Rakow, University of Houston-Clear Lake

The purpose of the Evaluation of Science I: Year One Implementation project was to form a base- line snapshot of the program as it existed. Although it would be desirable to compare the Science I program to the traditional Texas seventh-grade Life Science program, this

12.15 LEDBETTER CONTINUED

comparison would not be reasonable at this time. Measures for this study were Stages of Concern, Innovation Configuration, Test of Science Related Attitudes, State Anxiety Instrument, Hands-On Assessment, Middle Grades Integrated Process Skills Test, Demographics Instrument and Observation of Classroom Implementation Instrument. Preliminary data show positive attitudes toward the innovation. Results give a snapshot of implementation and form the basis for recommendations of further implementation and evaluation.

13.10

A TEACHER'S PROCESS OF IMPLEMENTING AUTHENTIC ASSESSMENT IN AN ELEMENTARY SCIENCE CLASS

Michael Kamen, Auburn University

The purpose of this study is to discover and describe factors that influence a teacher changing her assessment strategies in a hands-on, technologically-rich, elementary science class. There has been a great deal of support for assessment strategies that match the needs of quality hands-on science instruction. This is an ethnographic study which follows one teacher as she develops and implements authentic assessment strategies. This teacher incorporates both hands-on lab experiences and computers in her science instruction. In response to her graduate classes she decided to change her approach to assessment. She reported that her teaching was innovative, but that her assessment did not reflect her instructional goals. The following areas are the focus of this study: The factors that led the teacher to decide to change her assessment strategies; the steps the teacher went through in planning the assessment; the effectiveness of the assessment strategies at providing the teacher with the desired information; the level of support for the teacher from administrators, colleagues, and parents; and how the use of computers in the classroom affects the implementation of the assessment strategies.

13.12

ALTERNATIVE ASSESSMENT IN TEACHER PREPARATION SCIENCE METHODS COURSES

13.12 CONTINUED

Kathryn F. Cochran and April L. Gardner, University of Northern Colorado

This symposium provides overviews of various approaches to the use of alternative assessment in undergraduate science teacher education methods courses, and provides the audience with demonstrations of and opportunities to examine and discuss those methods. The use of technology-based unit designs, portfolios, problem oriented performance assessments, and concept mapping are included.

15.03

EVALUATING STUDENT CONCEPTION OF CONVECTION CURRENTS IN MULTIPLE CONTEXTS WITHIN EARTH SCIENCE

Ralph Feather, Derry Area Middle School, and
Michael J. Smith, University of Pittsburgh

The process of convection is encountered in multiple contexts within the domain of each science. A clinical interview was designed to reveal student conceptions of convection currents as they occur in air, water, and the earth's interior. The analysis of interview transcripts conducted with sixth and ninth-grade students, most of whom had completed a middle school earth science course, revealed four factors which influence children's conceptions of convection: a) Uninstructed students described the heating of water and air as a conductive process. b) Instructed students realize that convection occurs, but distinct differences exist in their conceptual understanding of why convection occurs. c) Thermal expansion and contraction are critically important concepts within the domain of convection. d) While older students use a more technical vocabulary, this does not necessarily produce a more accurate conceptual model of convection. The results of the study have been used to design and implement an instructional sequence which addresses the above-mentioned factors, particularly in making more explicit connections between laboratory models of convection and the process within the earth's interior. The curriculum and an analysis of the results of its implementation will also be presented.

15.03

ASSESSMENT OF BASIC PROCESS SKILLS FOR YOUNG CHILDREN

Meghan Mahoney Twiest, Indiana University of Pennsylvania

The purpose of this study was to investigate acquisition of basic process skills in children in kindergarten through grades three by developing an assessment instrument that would measure those skills. Preliminary research was conducted by using an existing paper and pencil test (BAPS) found to be reliable and valid for assessing basic process skills with students in the 4th through 8th grades (Padilla, Cronin & Twiest, 1985). Each question and answer was read to children ages 5 to 8. The children then responded after looking at the diagram (if one accompanied the question). Data was collected regarding the ability of each student to understand the question, the factors that confused the student, and the difficulty each child had in answering the question. With the data collected, a test of basic process skills is now being developed.

19.14

MIDDLE SCHOOL SCIENCE TEACHERS' PERCEPTIONS OF ASSESSMENT

Dorene Rojas Medlin, Dougherty County Public School System

Five middle school science teachers' perceptions of assessment, as measured by the Teacher Performance Assessment Instrument, were studied over the length of a complete evaluation cycle. Data were collected through a series of formal and informal interviews, as well as through written documents and observations of teacher performance. Analysis of data was completed using qualitative research methods. Middle school science teachers' perceptions of assessment were influenced by three major themes: Time, attitudes, and networking. The teachers held paradoxical views of each of the thematic areas. The interrelationships among the themes were examined and reported. The conclusions lead to recommendations related to teacher preservice training and teacher induction.

19.15

PERFORMANCE ASSESSMENT: INSIGHTS AND ISSUES FROM A LARGE-SCALE SCIENCE ASSESSMENT

Gaalen Erickson, Bob Carlisle, University of British Columbia,

19.15 ERICKSON CONTINUED

Tony Bartley, University of Victoria,
Karen Meyer, University of Toronto, and
Ruth Stavy, Tel Aviv University

Participants in this symposium will use the knowledge and experience gained from completing a large-scale performance assessment in the Province of British Columbia to raise a number of conceptual and methodological issues associated with this form of **alternative assessment** (Champagne & Newell, 1992). The educational and political context of the assessment setting will be described along with the procedures involved in constructing, administrating, and interpreting the results of two different types of performance tasks given to students at grades 4, 7, and 10. Finally, issues arising both from the data itself and from the nature of this type of assessment will be raised for discussion.

20.14

WHAT STUDENTS SAY ABOUT CLASSROOM SCIENCE

Patricia D. Morrell, Scio School District, and
Norman G. Lederman, Oregon State University

The purpose of this study was to investigate the attitudes toward science of elementary, middle and high school students, using a qualitative approach. Twenty five students were interviewed, using a structured interview format. These students were selected based on their responses on The Science Attitude Scale for Middle School Students (Misiti, et al., 1988). The chosen students either changed their attitudes toward science or were shown to have strongly positive, strongly negative, or neutral attitudes toward science. The interview data yielded some interesting insights into factors that affected students' attitudes toward classroom science. Based on the students' comments, students' attitudes were affected by their teachers' modes of instruction, amount of previous instruction, and relevancy of subject matter. Tenth graders also felt that achievement was linked to their attitudes toward classroom science.

22.05

A YEAR-LONG MIDDLE SCHOOL STUDY OF CONCEPT MAPS USED FOR INSTRUCTION AND ASSESSMENT CORRELATED WITH TRADITIONAL ACHIEVEMENT MEASURES

Diana Rice, Joseph Ryan, and Sara Samson, University of South Carolina

This set of three papers reflects a year-long study of concept maps used during instruction and as an alternative assessment procedure in middle school life science classes. The objectives of the study were to explore sychometric characteristics of concept maps including their validity as an alternative assessment procedure; to compare concept mapping with traditional objective-format tests; to evaluate the relationship of concept maps as instructional and assessment devices for students of varying ability. Gender and ethnic group differences are also examined. Participants in the study were 113 seventh grade students in a large suburban middle school. The study focused on five units of instruction spanning a six month period. Procedures for teaching concept mapping are described. Student attitude toward mapping varied though attitudes were unrelated to achievement. Minor ethnic and gender differences were observed. Student achievement in the form of concept map scores correlated significantly with unit-level multiple-choice tests as well as with standardized measures of achievement. The research project suggests that scoring concept maps using rubrics focusing on instructional goals and objectives rather than scoring maps based on structural characteristics may be a more valid approach to the use of concept maps as an alternative assessment procedure.

27.05

EVALUATION OF THE DOCTORAL PROGRAM IN SCIENCE EDUCATION AT THE UNIVERSITY OF GEORGIA

Gary Hill, Dee French, Lon Richardson, Randy Sparks, Carol Kight, and Thomas Koballa, University of Georgia

An interpretive research methodology was used to study the perceptions of current and former students and faculty about the doctoral program in science education. Sources of data included responses to a question about discrepancies noted between the current

27.05 HILL CONTINUED

doctoral program and stated program goals and responses to three questionnaires one developed specifically for each of the three populations--current students, former students, and faculty. The development of the questionnaires was informed by communication with both current students and faculty and by an instrument developed by faculty and students at the University of Texas at Austin. In addition to the initial analysis of data, current students and members of the faculty participated in a group interview for the purpose of constructing a complete interpretation of the data. Major conclusions regarding needed improvements include: (1) existing courses that constitute the doctoral program should be updated, not eliminated and replaced; (2) a formal mechanism is needed to inform students about research and financial opportunities within the department; (3) information should be provided about job opportunities other than academic employment; (4) more opportunities are needed for interaction between doctoral students and faculty; and (5) the two doctoral degrees (Ph.D. and Ed.D.)offered need to be made more distinctive or one should be dropped.

APPROACHES TO RESEARCH

5.17

INTRODUCTION TO AND COMPARISON OF RECENT VERSIONS SPSS/PC+ AND SAS(PC) WITH SPECIAL EMPHASIS ON MULTI-VARIABLE ANALYSIS IN SCIENCE EDUCATION RESEARCH

Kenneth Strand, Douglas Dirks, Gerald Foster, Dennis
Clodi, and Hae-Ae Seo, Illinois State University

The purpose of this paper is to compare recent versions of SPSS/PC+ and SAS(PC) utilizing an eclectic approach in which selected models are integrated with models implied in the Statistical Computing Software Reviews of the American Statistician and other publications. Special attention was allocated to the use of the software relative to multivariable statistical methods that may be applied to research in science education -- including multiple regression, discriminant, and canonical analyses as well as multivariate analysis of variance. The problem, interest, and importance concerning the purpose will be provided as well as the introduction to and comparison of the products, including (a) version and cost information, (b) market, (c) history, (d) hardware requirements, (e) installation, (f) data entry, (g) control language, (h) data-base management facilities, (i) statistical procedures, (j) performance, and (k) user comments, among other components.

6.07

MODELS FOR ACTION RESEARCH IN SCIENCE EDUCATION: THE TEACHER, RESEARCHER, AND STUDENT AS CO-INQUIRERS

Susan L Westbrook, North Carolina State University
James Minstrell, Mercer Island High School, Washington
Laura N. Rogers, Center for Mathematics and Science Education, North Carolina State University
Wolff-Michael Roth, Simon Fraser University

This symposium has been developed to promote dialogue concerning action research within the constructivist paradigm. The stories of three teacher-researchers and the questions generated from their research efforts will provide the framework for the presentation. Issues for consideration will include authentic assessment, the long-

6.07 WESTBROOK CONTINUED

term effects of action research, changes in the epistemological orientation of participating teacher-researchers, the social-intellectual environment of the classroom, and the necessary negotiation process required to assist students in the construction of their understanding of scientific phenomena.

7.04

EXPANDING THE HORIZONS IN QUALITATIVE DATA COLLECTION: A WORKSHOP IN USING LANs AS CAI EVALUATION TOOLS

B. James Hood, Middle Tennessee State University
Nancy D Green Glenn, Purdue University

This workshop will present the participant with actual experience with configuring both Macintosh and MS-DOS local area networks (LANs) for user data collection. One of the problems associated with CAI evaluating how the software is used. Users commonly experience problems with CAI software that may be a function of design factors in the programs and/or cognitive requirements. The former can be isolated from the latter by using LAN computers that have been configured for remote data collection. In this type of LAN, network administration software is used to observe the user to determine what actions that user did to cause software problems. The workshop presenters have found that this type of LAN is useful during alpha and beta testing of CAI software, and in qualitative research into CAI usage. Two types of LANs, Macintosh and MS-DOS, will be set up during the workshop by the participants. The software that is necessary for data collection will then be installed and data will be briefly collected. At the conclusion of the workshop, a summary of information concerning where the software and hardware may be obtained will be provided to the participants.

8.02

THE JOURNEY OF THE BEGINNER RESEARCHER: EXCITEMENT, PAIN, AND LEARNING

Hedy Moscovici, The Florida State University

The purpose of this paper is to analyze the influence of conducting

8.02 MOSCOVICI CONTINUED

research on the beginner researcher. Six stages were identified in the researcher's process of learning and change. These were: (1) a naive period in which the beginner researcher does not expect change in his relationship with the other participants as a result of his new position; (2) a revelation period in which the researcher begins to understand that the surrounding persons construct him differently in relationship with his new role; (3) a crisis period in which the researcher feels hurt by the attitude of the surrounding participants in the research; (4) a reflection period in which the researcher refines his role and analyzes his beliefs and actions in relationship with the research conducted. During stage five the research group is defining common goals related to the research. Stage six is the stage of not time limited reflection on what happened. All the participants in the research are learning and changing. For such a process, it is critical that a healthy relationship based on mutual trust and respect is developed and sustained.

8.02

A FRAMEWORK FOR SYSTEMATICALLY IMPROVING THE QUALITY OF SCIENCE EDUCATION RESEARCH

Martie Sanders, University of the Witwatersrand, South Africa

The quality of science education research has received criticism from many sources, including university academics in the **pure** sciences, science education researchers themselves, and the teachers who are expected to implement the research findings. If science education is to be taken seriously as an academic endeavor, and if the research results are to provide a meaningful contribution to improving the effectiveness of science teaching, it is vital that researchers ensure that their research does not contain flaws. The importance of improving research standards is reflected by the fact that the preparation of future researchers and upgrading of current researchers is one of the three responsibilities given to the recently established Science Education Research Agenda Coalition. This paper examines the criticisms levelled at science education research, and categorizes them by means of a concept map. It is suggested that this concept map could be used by science education researchers as a framework for

8.02 SANDERS CONTINUED

systematically checking their work, at both the design and the write-up stages, so that defects frequently identified in science education research can be detected and prevented.

10.05

BENCHMARKS FOR UNDERSTANDING THE NATURE OF SCIENCE: THE ROLE OF RESEARCH IN DEVELOPING PROJECT 2061 BENCHMARKS

Andrew Ahlgren, AAAS-Project 2061,
Susan Carey, Massachusetts Institute of Technology,
Pat Heller, University of Minnesota,
Richard A. Duschl, University of Pittsburgh, and
Deborah C. Smith, University of Delaware

This session addresses the relationship between educational and cognitive research and the development of appropriate learning goals on the nature of science. The process of developing Project 2061's benchmarks for grades 2,5, 8, and 12 has highlighted the need for more research on how children think and learn about the nature of science. Such research will be needed for revising the benchmarks and for developing curriculum based upon them. The panel will provide perspectives from different professional backgrounds on the **nature of science** benchmarks developed by Project 2061. Kinds of research proving most useful and further research needed in developing and revising benchmarks and curriculum on the nature of science will be identified.

15.02

INTRODUCTION TO AND SELECTED PROBLEMS IN DISCRIMINANT, CANONICAL, AND RELATED ANALYSES PERTAINING TO DATA ANALYSIS IN SCIENCE EDUCATION RESEARCH

Kenneth Strand, Douglas Dirks, Gerald Foster,
Tim Halloran, and Hae-Ae Seo, Illinois State University

The purposes of the paper are: (a) to demonstrate the current interest in discriminant, canonical, and related analyses; (b) to introduce discriminant, canonical, and related analyses, with special attention to standardized coefficients; (c) to present selected problems in discriminant, canonical, and related analyses; (d) to provide

15.02 STRAND CONTINUED

suggestions relative to how to deal with the selected problems identified; and (e) to apply all the above to research in science education. Selected problems are presented, as well as suggestions relative to how to deal with these problems including: (a) concerns relative to the literature pertaining to discriminant, canonical, and related analyses; (b) relevant statistical computing; (c) types of variables that may be used in discriminant, canonical, and related analyses; (d) special problems with categorical variables; and (e) skewness.

19.02

SYMPOSIUM: PRIORITIES FOR RESEARCH ON RURAL SCIENCE EDUCATION

J. Preston Prather, University of Virginia, and
William E, Baird, Auburn University

This symposium will include a report of results from a 10-state survey of rural teachers' perceived needs for science education and involve participants in an extensive examination of issues identified. Priorities for research will be presented, and participants will discuss options for multi-institutional collaborations to examine problems related to rural science teacher preparation and other issues. Much is known about the conditions and needs of rural schools, but in many cases the information lacks focus for decision making or further study. A long-range, structured program of research is needed to identify and examine alternatives and validate options for improvement of rural science education; and this symposium is designed to illuminate and promote that objective . Post-symposium discussions of issues will be continued through a monitored **Rural Science Education Network (RSEN)** established for that purpose. Attention will be given to developing a demographically representative, national network of 40 NARST members interested in participating in an on-going program for collaborative research on issues related to rural science education.

19.11

DEVELOPMENTAL RESEARCH AS A WAY TO AN EMPIRICALLY BASED DIDACTICAL STRUCTURE OF PHYSICS

P.L. Lijnse, University of Utrecht, The Netherlands.

19.11 LIJNSE CONTINUED

Research on pupils' ideas has drawn attention to the problems of learning physics. Proposed solutions are in general inspired by a constructivist cognitive science perspective and are formulated in terms of new teaching strategies. However, such solutions usually leave the conceptual structure of the curriculum unaltered. In our view, **developmental research** is needed in which small scale curriculum development is cyclically coupled to in depth classroom research of the teaching learning process. This should result both in practically worked out examples of new teaching strategies and in new conceptual curriculum structures. An empirically based related description of both teaching and learning activities and processes gives what we call a **didactical structure** for the teaching and learning of a particular topic. This constitutes a longer term research programme of which examples, for the topics of radioactivity and energy will be briefly discussed.

19.12

RECONSTRUCTING OURSELVES: COLLABORATIVE INQUIRY IN THE LIVES OF TWO SCIENCE EDUCATORS

Harold Grunau and Jazlin Ebenezer, The University of Manitoba

The study was designed to gain insight into the personal and professional growth of two science educators with full-time university appointments, as they conducted collaborative inquiry into their practice over a period of approximately one and one-half years. At the start of the study, one female participant was at the beginning of a career, while the other, a male, was in his twenty-fourth year at the same University. They observed one another teach, recorded observations and experiences using journals and logs, participated in audiotaped interviews and discussions with one another, and exchanged letters and written analyses of their observations and interpretations, as these emerged. The resulting case study of their collaborative inquiry centered around the close relationship between the participants' personal characteristics and professional performance and the strong relationships among research, experience and teaching, especially as these relationships underwent a transformation for

19.12 GRUNAU CONTINUED

both participants over the period of the study. Implications for practice were suggested by the differences in approach to their teaching which the two participants exhibited over time, and by the shifts in perspective and methods which occurred.

20.02

EVIDENCE FROM META-ANALYSIS FOR AN EXPERTISE MODEL OF ACHIEVEMENT IN SCIENCE

Michael Piburn, Arizona State University

A quantitative synthesis of multivariate studies in science education during the past ten years yields evidence to support a model of achievement in science very much like that currently proposed in the literature of expert problem solving. Despite previous claims, spatial visualization and memory capacity predict additional variance in achievement beyond that which they share with general intelligence. Both are also components of most theories of expertise. Cognitive ability, scientific reasoning, and prior knowledge all add further variance to the regression equation, and are demonstrably separate in their contributions to scientific achievement. Quantitative ability does not appear to be uniquely separate from cognitive ability. These results suggest an instructional program that focuses more on domain-specific skills and knowledge than on generalized and problem solving.

20.05

AN AGENDA FOR EVOLUTION EDUCATION RESEARCH

Ron Good and Jim Wandersee, Louisiana State University,
Charles Anderson, Michigan State University,
Kathleen Fisher, San Diego State University, and
Tony Lawson, Arizona State University

Informed contemporary biologists understand the importance of Darwin's theory of evolution, in its modern form, as the organizing framework for biological knowledge. The authors of Science For All Americans said it this way: The modern concept of evolution provides

20.05 GOOD CONTINUED

a unifying principle for understanding the history of life on earth, relationships among all living things, and the dependence of life on the physical environment. (p. 64) Despite the obvious importance of evolution education, relatively little research has been done to help us understand how conceptual change occurs as students move from less accurate to more accurate conceptions of evolution. This symposium will propose an agenda of research needed in evolution education, including the results of a December 1992 conference on the topic, sponsored by the National Science Foundation and Louisiana State University. The research agenda presented at this symposium will include recommendations for refining existing research designs as well as suggestions for new directions in evolution education research.

20.09

LINKING PROVINCIAL/STATE, PRIVATE, AND UNIVERSITY SCIENCE EDUCATION RESEARCH

Karen Sullenger, University of New Brunswick,
Mark Holland, New Brunswick Department of Education, and
Jamie Steele, Huntsman Marine Science Center

For the past two years three science educators have worked with classroom teachers to improve the teaching and learning of science. Independently and in collaboration, these educators began projects in elementary and secondary schools, and in local communities. Even when projects are undertaken individually, the three often find themselves in conversation with one another concerning possible links, mutual outcomes, and/or potential resources. However, they often find themselves making decisions without taking into account these considerations. How do three people who respect and like one another find themselves in circumstances where they often appear to be working at cross purposes? The answer is that these educators represent three different sectors of the science education community -- government, private interests, and the university. Although preservice and classroom teachers look to science educators for resources, guidance, and expertise, the educational and research goals, policies, resources, infrastructure, outcomes, and interests are different for science educators in each of these,sectors. Is the nature

20.09 SULLENGER CONTINUED

of the relationship among government, private interests, and university-based science educators problematic? What should be the relationship among the various sectors of the science education community -- e.g. coordinated, isolated, independent, but collaborative? Using the experiences of these three science educators as a case in point, we would like to involve participants in discussing issues and in proposing a working model that could be used as an initial framework.

21.12

THE PATH TO QUALITY LEARNING

Richard T. White, Monash University

Current concerns about the quality of learning encourage a synthesis of two strands of research: alternative conceptions and metacognition. Although metacognition shows promise as the solution to problems of alternative conceptions, there is insufficient evidence about this. Unfortunately, studies that investigate whether successful training in metacognition reduces the incidence of alternative conceptions are likely to be rare, because training of metacognition has to be long and intense. A serious problem is that many students resist training in metacognition because they have unsympathetic perceptions of the purpose of schooling and of what constitutes success in learning. Perceptions that learning is rote memorization of facts and drilled performance of algorithms are created by poor teaching. Practical solutions to the development of metacognition, the reduction of alternative conceptions, and the promotion of quality learning are the introduction of diverse methods of teaching that require students to be active in learning and diverse forms of test that resist rote performance. Examples of both are available from research.

24.02

THE RESEARCH ON LEARNING TO TEACH SCIENCE: PROSPECTS AND PROBLEMS

Barbara J. Moon and Marvin F. Wideen, Simon Fraser University, and Jolie A. Mayer-Smith, University of British Columbia

24.02 MOON CONTINUED

A literature review of research in science teacher preparation was undertaken and compared to research studies of generic teacher preparation. These two literature areas were examined with a view to ascertaining whether there is some common ground from which to view the generic and subject specific case studies on learning to teach. Thirty-four case studies were reviewed in which there was sufficient information about specific conceptual elements and program influences to be used as an over all frame for analysis. The results of this review provide a basis for further research in the area of science teacher preparation.

27.02

A NATIONAL RESEARCH AGENDA FOR GENETICS PROBLEM-SOLVING

Mike Smith, Mercer University,
Patricia E. Simmons, The University of Georgia, and
Judith Kinnear, The University of Sydney

This symposium is intended to:

1. provide a forum for interactive dialogue about research issues on genetics problem-solving;
2. discuss current research and the need to extend research in genetics problem-solving;
3. report the recommendations for research and classroom practice from a National Science Foundation (NSF)-sponsored national meeting of science teachers, science educators, scientists, and researchers in problem-solving and genetics problem-solving;
4. discuss the implications of this national research agenda for conducting, disseminating, and implementing research efforts by the science education community to respond to real instructional needs of students.

The critical questions that served as discussion points at the conference were: l) What does research say about how teaching problem solving in the sciences,should be done? 2) What are effective classroom instructional strategies? 3) What research questions that will inform learning and teaching need to be asked? Recommendations for research in genetics focused on the following areas: conceptual

27.02 SMITH CONTINUED

knowledge and understanding, problem solving, nature of science/genetics, desired student characteristics, and the teacher's role. One specific recommendation for research which emerged from conference participants was the development of a consortium for research on the learning and teaching of genetics.

27.14

RESEARCH IN SCIENCE EDUCATION: NATIONAL SCIENCE FOUNDATION INITIATIVES

Janice Earle, Marjorie Enneking, Larry Enochs, Raymond Hannepal, and Jean Vanski, National Science Foundation

The purpose of this symposium will be to discuss present research efforts funded by National Science Foundation (NSF). Additionally, new directions and possibilities will be discussed. At present, the only funding specifically directed toward research is in the Research on Teaching and Learning Program. However, research components are present in several Education and Human Resources Division (EHR) projects. Each participant will address research funding implications as it applies to their Program. In addition to discussing the current Programs, future research directions within EHR will be addressed.

28.08

REPORT OF THE NSTA/AAAS/NARST TASK FORCE FOR DEFINING A RESEARCH AGENDA IN SCIENCE EDUCATION

Emmett L. Wright, Kansas State University

The Task Force has been in existence for the past three years. The major purposes of the Task Force are to: 1. provide leadership through various coalitions with agencies that are concerned with the improvement of science teaching and learning. 2. Articulate parameters for science education research. 3. Summarize and disseminate the findings of science education research in a manner that is useful for both researchers and practitioners. 4. Develop effective means for the application of research to science teaching and learning. 5. Enhance quality of science teaching worldwide through research and policy development. The specific objectives of the Task Force Report

28.08 WRIGHT CONTINUED

that have been accomplished over the past three years and steps planned for the future will be discussed.

CONCEPTUAL CHANGE

5.09

THE STRUCTURE AND USE OF BIOLOGICAL KNOWLEDGE IN NOVICE AND EXPERIENCED STUDENTS: MAMMALS III

M. Gail Jones, University of North Carolina at Chapel Hill, and Kimberly M. Markham and Joel J. Mintzees, University of North Carolina at Wilmington

This study examines structural differences in the knowledge bases of novice and experienced students within the domain of mammals. A sorting task related to mammals was given to introductory and advanced college biology students, (n=50) to examine differences in the use of inferential reasoning and the ability to use large, meaningful patterns in assigning class membership. Multidimensional scaling revealed differences in introductory and advanced college biology students' organization of their knowledge of mammals. The advanced students used a larger repertoire of implicit, superordinate concepts to order their concepts. The advanced students also tended to assign class membership based on a taxonomically acceptable system of reproductive strategies and nutritional patterns.

5.09

THE STRUCTURE AND USE OF BIOLOGICAL KNOWLEDGE IN NOVICE AND EXPERIENCED STUDENTS: MAMMALS I

Kimberly M. Markham and Joel J. Mintzees, University of North Carolina at Wilmington, and
M. Gail Jones, University of North Carolina at Chapel-Hill

This study explored structural differences in the knowledge bases of novice and experienced students. Subjects were introductory and advanced college biology students (n=50). Each subject constructed a concept map on **mammals**. Participants then generated an exhaustive set of descriptive propositions in a clinical interview which focused on mammals depicted in 20 labelled line drawings; and subsequently sorted the line drawings into homogeneous groups. Part I of this report presents the findings of the concept mapping task. Results reveal that experienced students possess a substantially more extensive, complex,

5.09 MARKHAM CONTINUED

and integrated knowledge base characterized by significantly greater numbers of concepts, relationships, levels of hierarchy, branchings, and crosslinks.

5.09

THE STRUCTURE AND USE OF BIOLOGICAL KNOWLEDGE IN NOVICE AND EXPERIENCED STUDENTS: MAMMALS II

Joel J. Mintzees and Kimberly M. Markham, University of North Carolina at Wilmington
M. Gail Jones, University of North Carolina at Chapel-Hill

Part II of this report provides further evidence of structural differences in the knowledge bases of novice and experienced students within the domain of mammals. Additionally, we show that these differences are related to qualitative superiority among experienced students in the use of inferential reasoning. Results of clinical interviews with introductory and advanced college biology students (n=50) reveal several significant trends favoring the latter group, including: (I) the emergence of a vast, new repertoire of implicit, superordinate concepts which orders students' understandings about mammals; and (2) the enhanced use of inferential reasoning strategies which enable students to deduce knowledge that is not explicitly observable.

6.1

INVESTIGATION OF HIGH SCHOOL CHEMISTRY STUDENTS' CONCEPTS OF CHEMICAL SYMBOL, FORMULA, AND EQUATION: STUDENTS' PRESCIENTIFIC CONCEPTIONS

Ali A. Alkunifed, and Ronald G. Good, Louisiana State University

This study investigated 11th grade high school chemistry students' understandings of the concepts of chemical symbol, formula, and equation. A combination of quantitative and qualitative methods were employed in a two-stage pattern comprising a preliminary and main study. In addition, the school teacher was an active participant throughout the research process. Three open-ended essay questions were asked to conduct the preliminary study. The findings of this stage

6.1 ALKUNIFED CONTINUED

were the focus of the main study. Clinical interviews were used to conduct the main study on the teacher-selected sample (18 students), and the interviewees were involved in three actual chemical reactions. Preestablished criteria and content analysis were used in data analysis as well as two groups of experts for the purpose of validity and reliability. This study identified students' conceptual difficulty and possible prescientific conception and their cause/sources. Recommendations and implications for science teachers, curriculum developers, and project 2061 were addressed.

6.1

QUALITATIVE INTERPRETATION OF A LEARNING PROCESS IN ELECTRIC CIRCUITS

Hans Niedderer, University of Bremen, Germany, and
Fred Goldberg, San Diego State University, California

Our learning process study with three college students focused on a microanalysis of thinking and learning during an open-ended instructional unit of electric circuits. A locally developed computer-video software program using a pressure representation of potential was used to provide students with a tool to develop their own ideas in the context of predictions and explanations of experiments with batteries and bulbs. The whole process of six sessions was videotaped and transcribed. In this paper we present some results out of an interpretive analysis about the learning process itself. We show how "old" cognitive elements (e.g. the idea of sharing currents) stay stable and are used in new contexts during the learning process, and how other **new** cognitive elements (e.g. a microscopic view of electron movement) are developed from the teaching input and are used throughout the whole learning process. There is also evidence that some elements of the instruction do not get a strong resonance in students' own reasoning.

6.15

CLASSROOM ENVIRONMENT AND CONCEPTUAL CHANGE INSTRUCTION

Michael Beeth, University of Wisconsin-Madison

6.15 BEETH CONTINUED

This paper describes a research study conducted in a classroom environment devoted to conceptual change instruction. The teacher in this class of fifth grade students made explicit attempts to have her students comment on the conceptions they held, their justification for those conceptions and the status attached to their conceptions. Students' comments about their conceptions allowed the teacher to assess their scientific knowledge while comments justifying a conception or determining status were used to assist students through the process of conceptual knowledge development (i.e. how could the teacher facilitate concept development and how could she determine the level of commitment a student had to a conception?) As a result of students' comments, the teacher planned instructional activities that focused on specific aspects of the Conceptual Change Model, namely the conceptual ecology and status. The learning environment in this classroom, created by the interaction between students' responses to planned instructional activities, facilitated the development of students' conceptions.

6.15

STUDENTS' IDEAS ABOUT THEIR CONCEPTUALIZATIONS: THEIR ELICITATION THROUGH INSTRUCTION

M. Gertrude Hennessey, St. Ann's School, Stoughton, WI, USA

This paper draws on the findings of three distinct but conceptually related studies in order to: (1) consider the role of metacognition for conceptual change; and (2) explore the extent to which students are metacognitive at varying grade levels. Each study was conducted in three phases. Phase 1: Students learned the technical language of the conceptual change model (CCM); shared meanings for each term were negotiated by consensus. Phase 11: Data was collected at intervals having the students (grades 2-6) comment on both the status and content (basic concepts: force & motion, heat transfer, particulate nature of matter, gravity, cause of seasons) of their ideas. Phase 111: After an extended time interval further data about status and content was gathered. The data provides rich detailed accounts of the students' reflective thoughts. Analysis of metacognitive discourse reveals: (1) individual students can and do engage in metaconceptual activities, i.e.,

6.15 HENNESSEY CONTINUED

determine status, become aware of the content of their ideas, and discuss the process of their own thinking; (2) both students and teacher can be metacognitive with each others' ideas; (3) metacognition happens across the grade levels with increasing sophistication; and (4) status determination can be determine from both technical and non-technical classroom discourse analysis.

8.04

PROBLEM SOLVING AND COGNITION IN CHEMISTRY

Mary B. Nakhleh, Purdue University
Eileen L. Lewis, Canada College and University of California, Berkeley
Amy J. Phelps, University of Louisville, and
George Bodner, Purdue University

Researchers in chemistry education are beginning to realize that chemical knowledge is represented in multiple ways and that these multiple representations are often confusing to students. Therefore, students who struggle to construct appropriate understanding of chemistry topics and demonstrate that understanding by solving problems must understand these representations and become adept at using them. Researchers are building a model of these multiple representations as involving macroscopic, microscopic, symbolic, and algebraic modes of understanding. A variety of qualitative and quantitative methodologies have been used in investigating this model. In order to promote discussion of the future research needed to identify and clarify the ways in which these modes of representation influence the construction of appropriate understanding, the presenters at this symposium report on (l) undergraduates' differential performance on conceptual versus algorithmic exam questions; (2) the conceptual models and strategies which undergraduates and professors employ in working nonstandard problems; (3) problem solving in the context of high school and college classrooms; and (4) the multiple representations used by undergraduate organic students and graduate students.

8.09

THE EFFECT OF TEACHING STRATEGIES USING MODELS ON PRESERVICE ELEMENTARY TEACHERS' CONCEPTIONS ABOUT EARTH-SUN-MOON RELATIONSHIPS

Priscilla L. Callison, University of Missouri-Columbia, and
Emmett L. Wright, Kansas State University

Do hands-on teaching strategies using models effect preservice elementary teachers' conceptions about the earth-sun-moon? The results suggested at least one of the treatment strategies (Semiconcrete-External) may have some effect on conceptual change or development. Two additional factors were tested and correlated to subjects' abilities to develop an explanatory model: reasoning level and spatial rotational ability. Of the two factors,only reasoning level was positively correlated. Randomly selected subjects were interviewed to gain further insight into their thinking about earth-sun-moon relationships. Most misconceptions revealed through the interview were consistent with the literature. One subject stated that the moon and the sun **were the same thing** with the sun visible during the day and the moon visible at night. Results suggest that teachers need to use physical models of abstract concepts which aid in the development of conceptual models.

8.09

THE EFFECTIVENESS OF LARGE-SCALE, TEACHER-VALIDATED DIAGNOSIS AND CONCEPTUAL CHANGE DISCUSSIONS IN REMEDIATING THE ALTERNATIVE CONCEPTIONS OF HIGH SCHOOL BIOLOGY STUDENTS

Andrew McConney, Phillip B. Horton, and Amanda L. Woods, Florida Institute of Technology, and
Carolynn Howell, Palm Bay High School

This in-school study used a quasi-experimental design to investigate the effects of alternative framework diagnosis and biology concept discussions on the misconceptions and achievement of high school biology students. Eight secondary school teachers who participated in a two-day constructivist workshop validated a diagnostic instrument modeled after suggestions offered by Treagust (1988). These teachers then administered this diagnostic instrument to 20 intact classes randomly assigned to treatment and control protocols, and comprised of

8.09 MCCONNEY CONTINUED

511 biology students. Teachers used the analyses of the results of this pretest in experimental sections to guide student-centered biology concept discussions which took place for 15-20 minutes during every other class period. Topics included the scientific method, spontaneous generation, characteristics of life, and basic chemistry (the nature of matter and matter-energy relationships); the treatment took place over a nine-week period. Preliminary analysis of results indicate that alternative conceptions in the biology topics under consideration are remarkably stable across gender and age. However, previous exposure to these biology topics did notably decrease the number of naive conceptions students hold. The summative success of this diagnosis-conceptual change protocol will be further considered from both teacher and student perspectives.

8.11

CHILDREN'S PERSPECTIVES ON CAMP AND SCHOOL SCIENCE

Christa R. Winter, Lewis and Clark College

Fifteen boys and eight girls ages seven to ten were interviewed before and after they attended summer science camps organized by the Oregon Museum of Science and Industry. Interviews included questions about learning in school and at camp, children's attitude toward science and their notion of science and scientists. In general, children described school science as sitting at a desk, listening to lectures, reading and answering questions in their textbook, and filling out worksheets. In comparison, camp science provided choice of activities, hands-on-learning, experiments, real-life experiences, and group interaction. Children advocated camp science because they felt that it was more engaging and they learned more. They reported a more positive attitude toward science after camp, and some indicated that science camp changed their conception of science. The findings support current efforts that introduce constructivist and female-friendly approaches to science learning and aching in our schools.

12.09

THE CONCEPTUAL CHANGE MODEL AS A BASIS FOR ELEMENTARY SCIENCE TEACHER EDUCATION

Peter W. Hewson (Discussant), University of Wisconsin-Madison,
Lois M. Campbell, Pennsylvania State University,
René T. Stofflett, Northern Illinois University, and
N. Richard Thorley, University of Rochester

The Conceptual Change Model was initially proposed as a model of students' learning of scientific conceptions. In this session, the participants will explore the wider application of model: To the development of scientific conceptions among preservice elementary science teachers, and to the transitions that must occur in their conceptions of teaching and learning. These transitions have been investigated through a variety of techniques, including analysis of reflective essays, classroom observations and interviews. The various dimensions of the model will be examined through a discussion among the four participants, rather than in separate presentations. Particular emphasis will be placed on the meanings that preservice teachers attribute to both scientific conceptions, to the process of, and to conditions for conceptual change.

12.09

ACCOMMODATING PEDAGOGICAL CONCEPTIONS IN AN ELEMENTARY SCIENCE METHODS COURSE

René T. Stofflett, Northern Illinois University

This paper describes an elementary science methods course that was developed using the scientific accommodation model. The research examined whether the course facilitated the accommodation of preservice teachers' (n=40) pedagogical conceptions. Intelligibility was developed via a conceptual change content intervention. Plausibility then grew out of the explicit contrast to previous content learning experiences in didactic courses. Dissatisfaction occurred when the teachers realized the conceptual change model was more effective than didactic models their former professors and cooperating teachers had used. Fruitfulness was facilitated in the field experience when the students had the opportunity to apply the methods into practice in real

12.09 STOFFLETT CONTINUED

classrooms. Research such as this can aide the development of more effective science methods courses.

13.05

GIFTED ELEMENTARY STUDENTS PARTICIPATION IN A BIOCHEMISTRY ENRICHMENT PROGRAM

Lloyd H. Barrow, University of Missouri-Columbia, and
Hsiao-Ching She, Taiwan Normal Teacher University

The purpose of this study was to examine how the level of self-concept of gifted elementary students relates to their participation in a biochemistry enrichment program. The ME: Self-Concept Scale (Feldhusen & Kolloff, 1981) was utilized to categorize the 18 students. Each of two levels of self-concept groups (High and Low) were divided into three paired groups: Girl-boy, boy-boy, and girl-girl. Rennie's Classroom Observation System (1985) was used to measure the extent and nature of the children's participation. Low self-concept students tended to ask more questions and receive more feedback than high self-concept students. Boys tended to initiate more questions and had more call outs while two girl groups had more peer interaction. Within boy-girl groups, the boys did more manipulating while girls watched and discussed with other groups.

13.05

FOURTH GRADERS' CHANGE IN CONCEPTUAL UNDERSTANDINGS OF ELECTRIC CIRCUITS

Daniel P. Shepardson, Elizabeth B. Moje and Sandra K. Abell, Purdue University

Preliminary findings suggest that children's preinstructional conceptual understandings of electric circuits were scientifically inappropriate and inconsistent across circuit problems. After completing the instructional unit all children exhibited conceptual change, but their conceptual understandings of electric circuits remained scientifically inappropriate or incomplete. However, children's explanations were more conceptually consistent across circuit problems. Further, children's general rules for explaining how to make a bulb light reflected a

13.05 SHEPARDSON CONTINUED

move from rules that were vague and incomplete to rules that encompassed major aspects of electric circuits. Thus, enabling children to generalize their rules to a variety of circuit problems.

13.05

SO,WHAT DID YOU EXPECT?: EXAMINING STUDENT UNDERSTANDING OF THE CONCEPT OF BALANCE

Susan L. Westbrook and Laura N. Rogers, North Carolina State University and
M. Jayne Fleener, The University of Oklahoma

This study examined the effect authentic classroom instruction had on the understanding of balance held by four ninth grade physical science students. A variety of assessment techniques were employed in the study: video-taped interviews, video-and audio-taped laboratory sessions, audio-taped classroom discussions, pencil and paper accounts of mathematical problem solving, daily paper work completed in the classroom, and classroom quizzes. Analysis of the written and transcribed data indicated that the students began their understanding of the concept of balance by thinking of balance as a **thing**. As an understanding of balance (a state relative to the position of an object) developed, the students verbalized the need to control distance and maintain equal weights. Ultimately, the students recognized that balance was dependent on the interactions of weights and distances. Students who reasoned proportionally were able to utilize the classroom activities and construct an understanding of balance that allowed for problem solving several weeks after the unit on balance was complete. Students who did not reason proportionally did not indicate problem-solving ability after the conclusion of the unit. A discussion of teacher/researcher expectations of student achievement within the framework of impending reform is included.

15.05

THE EFFECT OF INSTRUCTION TO PARENTS ON QUESTIONING AND THE LEARNING OUTCOMES OF THEIR CHILDREN DURING A FAMILY SCIENCE CLASS

Andrea V. Anderson, The Association of Science-Technology Centers

15.05 ANDERSON CONTINUED

Science museums offer family learning programs to enhance the scientific literacy of children. This study examined whether teaching parents about questioning skills would change the number and kinds of questions parents asked children and what effect it had on children's learning outcomes. Participants were self-selecting family groups involving 60 children, ages 6 to 11, and their parents. Randomly assigned, parents received either a placebo or intervention treatment about asking questions. Parent-child conversations were audio taped and the **parent-talk** coded on forms designed by the researcher. Concept acquisition, science process skills, and attitudes of children were measured. Demographic data on parents were collected. Hotelling T^2 test was used to determine treatment effects. Findings indicate parents could be encouraged to include more higher level thinking questions, but the effect appears to be moderated by the age of the child and the nature of the class. No significant differences were found for either concept acquisition or science process skills. Attitudes were somewhat affected by treatment that parents received.

15.05

MULTIMEDIA, MISCONCEPTIONS, AND WORKING MODELS OF BIOLOGICAL PHENOMENA: LEARNING ABOUT THE CIRCULATORY SYSTEM

Barbara Buckley, Stanford University

This naturalistic cognitive case study was conducted in a technology rich classroom of tenth grade biology students who had access to an interactive multimedia resource entitled **Science for Living: the Circulatory System** (SFL) during a 3-week unit on the circulatory system. From videotape, video quiz, interview, card sort, and computer trace data a rich description of what and how two students learned about the circulatory system, situated within the quantitative context of their classmates' scores on written pre and post tests, was constructed. One student was characterized as a biology learner trying to understand and explain the phenomena who used the information and simulations in SFL to answer her own questions about the structure, function, behavior and mechanisms of the circulatory system. The other student was characterized as an average school learner who tried to describe circulatory system behavior without mechanisms and used

15.05 BUCKLEY CONTINUED

SFL primarily for project production. From data analysis emerged the definition of a working model of the circulatory system, its concise representation, and the hypotheses (a) that learning biology well means building working models of phenomena and (b) that technology may facilitate model-building by providing access to and control of linked, multiple dynamic representations of those phenomena.

15.05

A COMPARISON OF KNOWLEDGE DOMAINS USED BY AN EXPERIENCED AND NOVICE TEACHER FOR PLANNING TO TEACH A CONCEPT IN SCIENCE

Carolyn Keys, University of Michigan

The purpose of this study was to Investigate the amount, type, and organization of knowledge used by an experienced and novice teacher, while planning Instruction for a specific science concept. An experienced earth science teacher and a preservice earth science teacher were asked to plan lessons for the concept, **why we have the four seasons** out loud. Statements made by the teachers during the think aloud simulation were coded according to the knowledge domain represented. The coding categories Included general pedagogical knowledge, content knowledge, and pedagogical content knowledge, which Included the subcategories of student understanding and topic specific strategies. The experienced teacher generated a total of 226 statements about instruction for this concept, while the novice teacher generated 76 statements. The most frequently represented domain for the experienced teacher was topic specific strategies, while that of the novice was general pedagogical knowledge. The knowledge of the experienced teacher was organized around five distinct elements of lesson structure, while that of the novice appeared to be accessed in a random manner. Implications for teacher education are discussed.

15.05

STUDENT BELIEFS CONCERNING INHERITANCE AND NATURAL SELECTION

B. Kim Nichols, The University of Georgia

Three students were interviewed to determine their views Concerning natural selection, adaptation and inheritance. The subjects include a thirteen year-old male, a twenty-one year-old male, and a twenty-one year old female. The thirteen year-old has just completed a year of middle school life science; the twenty-one year old male has completed one year of junior college coursework but has not taken biology since the tenth grade. The twenty-one year old female has completed two quarters of introductory college biology at a large university. The interviews reveal numerous alternative conceptions--many of which are remarkably similar among respondents. Interestingly, the youngest participant gave the most accurate explanation of biological adaptation. The college female is familiar with more scientific terminology but is not certain of the correct usage of the terms. The alternative conceptions expressed are quite tenacious since some persist even after college biology instruction.

15.05

USING CONCEPT MAPS TO EXAMINE NINTH GRADE STUDENTS' CONCEPTIONS OF ELECTRICAL CIRCUITS IN A LEARNING CYCLE CLASSROOM

Phares L. Sechler, Laura N. Rogers, and Susan L. Westbrook,
North Carolina State University, and
M. Jayne Fleener, University of Oklahoma

Ninth-grade students' conceptions of electrical circuits were examined using concept maps constructed before, during, and after instruction. Additional assessments included drawings, graphs, definitions, explanations, and mathematical problems. The students in the study were enrolled in a physical science course taught using the learning cycle format. The concept maps of ten students were examined to determine the degree to which the students' laboratory experiences were reflected in the maps. Novak's (1990) assertion that a student's mapping structure reflects concept understanding was examined by comparing the mapping structure to information communicated in

15.05 SECHLER CONTINUED

other written assessments. Preliminary analysis indicated that students tended to place concepts from laboratory experiences at the top of the map and concepts that they knew less about at the bottom of the map. A discussion of the traditional interpretation of concept maps (Novak & Gowin, 1984) and a scoring matrix consistent with the philosophical constructs of a laboratory classroom are included.

15.05

THE EFFECTIVENESS OF HYPERCARD SIMULATION: AN EXAMINATION OF AMERICAN NINTH-GRADE STUDENTS' DECISION-MAKING PROCESSES ON MUNICIPAL SOLID WASTE MANAGEMENT

Kuo-Hua Wang, National Changhua University of Education, Taiwan, R.O.C.

This study determined cognitive activities, as shown by American ninth-grade students, involved in decision-process on solid waste management by using HyperCard™ simulation as an instructional tool. The simulation was designed to record those outcome variables including option ranking order and protocol, reaction time (including information viewing time on each card and option ranking time), and cards in the stack read by the student. The result showed that the students did improve their option-ranking score after the trials. The average student read 29% of the total information provided in the simulation by using a conjunctive information-searching strategy (satisfying strategy) instead of using concise systematic strategies to search for information. A significant negative relationship appeared between the number of cards read and student option-ranking scores. Spending more time (seconds) on cards yields better option-rankings. However, the option-ranking score was affected by the total time spent on the simulation in general but not by any particular card. Finally, a treatment-aptitude effect was shown by the students.

15.05

ACCURATE AND INACCURATE CONCEPTIONS ABOUT OSMOSIS THAT ACCOMPANIED MEANINGFUL PROBLEM SOLVING

June T. Zuckerman, SUNY--The College at New Paltz

15.05 ZUCKERMAN CONTINUED

Meaningful problem solving is problem solving that is driven by appropriate and essentially accurate conceptual knowledge. This paper is about the meaningful solving of an important problem about osmosis. This paper identifies, for a meaningful solving, (a) accurate conceptions about osmosis that could be useful for a correct answer and (b) inaccurate conceptions about osmosis that could either preclude or be concealed by a correct answer. The investigation consisted of a presolving clinical interview, think-aloud solving of the problem, and retrospective report of the solving. The solvers were 14 outstanding science students who had been unfamiliar with the problem. Only six generated meaningful solvings; 3 of the 6, correct answers as well. These six meaningful solvers evidenced a total of 12 accurate and 8 inaccurate conceptions about osmosis. One inaccurate conception has yet to be reported in the science education literature.

19.09

ANALYZING STUDENTS' SCIENTIFIC ARGUMENTS AND ARGUMENTATION PROCESSES

David Eichinger, Purdue University

This study examined how individuals and groups of students constructed scientific arguments as they engaged in a series of collaborative problem solving activities. The study was based on research traditions in conceptual change, social semiotics, and argumentation. Two research questions were investigated: a) What is the nature of students' scientific arguments and how do they approximate or fail to approximate scientists' arguments for relatively complex scientific problems?; and b) Does the nature of students' arguments and argumentation processes change over time, and if so, in what ways? Two target groups of four students each were videotaped during three months of instruction in a sixth grade science classroom. Data analyses focused primarily on an examination of students' small group discussions of four collaborative activities that addressed aspects of the kinetic molecular theory. In general, the results show much variability in the degree of scientific and logical sophistication that students developed in their individual and group arguments during their study of the curriculum unit. While a few students demonstrated

19.09 EICHINGER CONTINUED

significant progress in their understanding and application of scientific forms of argumentation, the majority of students continued to approach and solve these problems in much less complex and sophisticated ways.

19.09

DISCOURSE DURING SCIENCE LABORATORY EXPERIENCES: FACILITATION OF CONCEPTUAL UNDERSTANDING THROUGH EFFECTIVE ARGUMENTATION AND GROUP WORK

Joanne Striley, Gail Richmond, and Charles W. Anderson, Michigan State University

This study examines the nature of student discourse during laboratory work undertaken by two groups of high school students in a team taught 10th grade interdisciplinary science course. Student laboratory activities were videotaped over the course of three scientific case studies involving student generated research. Individual and group products and assessments were also collected. Data were analyzed to characterize patterns of group interaction during laboratory activities which contribute to: The design of effective empirical tests; fruitful and productive analysis of these tests; the production and elaboration of scientific arguments which are persuasive to peers; and individual gains in conceptual understanding and science process skills.

19.09

DISSERTATION DATA UPDATE: APPROPRIATING SCIENTIFIC INTELLECTUAL AND SOCIAL CONVENTIONS

Randy Yerrick, Michigan State University

This study investigated how lower track high school students made sense of attempts to modify their intellectual and social conventions from those found In traditional classrooms to those of a more scientifically literate community of learners. Two aspects of student learning were studied. The first was the acquisition of scientific argumentation as described by Toulmin's (1958) model. The second was the set of social conventions that enhanced or impeded the development

19.09 YERRICK CONTINUED

of argumentation. Videotapes were made of daily instruction and analyzed. Results indicated that an individual's acquisition of intellectual conventions does not necessarily occur synchronously with social conventions. Students became more accustomed to using evidence to argue scientifically. Areas of change included reliance upon the teacher as authority, collaboration, and acceptance of all members as contributors to a socially constructed best answer.

20.06

INVESTIGATING STUDENTS' RECALL OF NEWTON'S LAWS OF MOTION THROUGH SCHEMA THEORY AND SPORTING ACTIVITIES

Timothy Daponte, Reagan High School, and
Eugene Chiappetta and Richard Hamilton, University of Houston

A sample of 360 high school students enrolled in physical science was randomly assigned to one of four treatment groups to participate in enrichment activities including those: (1) written in a declarative style, (2) written to describe sports activities, (3) written to describe vehicular motion, and (4) to read **The Jungle** by Upton Sinclair. Following the treatments, the subjects in each group were randomly given one of three different tests on Newton's three laws of motion - a declarative, a sports, or a vehicular test. The results showed that the subjects who participated in the enrichment activities that addressed the sports schema scored higher than the other students. This investigation adds support to the idea that science achievement can be influenced by developing science subject matter around what students are interested in.

20.06

ALTERNATIVE FRAMEWORKS OF MOTION, FORCE, HEAT, AND TEMPERATURE: A SUMMARY OF STUDIES FOR STUDENTS IN TAIWAN

Chorng-Jee Guo, National Changhua University of Education

The author has led in recent years a series of studies on students' alternative frameworks of motion and force, and of heat and temperature, respectively. The students investigated in these studies were not the same. They varied from grades five and six in elementary

20.06 GUO CONTINUED

schools to grades seven and eight in junior high schools. Self-developed paper-and-pencil tests were used to probe students' conceptual understandings of a range of phenomena presented in the problem situations. Analysis of students' responses to the test items yielded preliminary results on students' alternative conceptions of some particular events and/or situations. In each study, a number of typically ten students having alternative conceptions which were shared by many students were selected for in-depth interview. Students' alternative conceptions which were determined from both the written tests and the interviews were cross-checked and synthesized. Efforts were then made to identify students' alternative frameworks according to an operational definition introduced in these studies A summary of the results obtained is given in this article.

20.06

A STUDY OF CHANGES IN HIGH SCHOOL STUDENTS' UNDERSTANDING OF SELECTED CONCEPTS IN PHYSICS

James A. Shymansky, University of Iowa,
David F. Treagust, Rodney B. Thiele, Allan Harrison, Bruce G. Waldrip, Susan M. Stocklmayer, and Grady Venville, Curtin University, Perth, Western Australia

Proponents of constructivist learning claim that meaningful learning occurs only when ideas are linked together by the learner in a conceptual framework. They further claim that understanding progresses, remains unchanged, and sometimes regresses as these frameworks are restructured. In a study of changes in teacher understanding of selected science concepts, Shymansky and his co-investigators observed evidence of apparent conceptual growth, stability and regression using concept maps generated by the teachers across a six-month inservice program. In the study presented here, 21 students in a high school physics course were monitored across a four-month period using a combination of student-generated concept maps and follow-up interviews to determine if conceptual growth, stagnation and regression similar to that reported by Shymansky et al. for the teacher sample also occurred. Comparisons of the teacher and student conceptual change patterns are discussed.

22.03

LEARNING ENVIRONMENTS: SENSE-MAKING IN THE CLASSROOM

Lon Richardson, Patricia E. Simmons, The University of Georgia, and
Barry Fraser, Peter Taylor, Curtin University

This symposium is intended to:

1.Provide a forum for interactive dialogue about research issues on learning environments; share a new research strategy which assesses the progression of teachers' and students' perceptions of the learning environment and their control over the flow of causality within that environment.

2. Provide an opportunity for participants to reflect on and discuss this strategy and the resulting profiles of selected cases of representative teachers.

3. Discuss current research and the need to extend research in learning environments.

4.Synthesize and discuss the implications for research on learning environments on an individual, classroom, and institutional basis (strategies for intervening and changing the learning environment).

22.09

TEACHER USE OF KNOWLEDGE OF STUDENT HELD PHYSICAL SCIENCE CONCEPTS PRIOR TO INSTRUCTION: A CASE STUDY OF SIX SCIENCE TEACHERS

Bobby J. Franklin, Louisiana Department of Education, and
Ronald G. Good, Louisiana State University

The purpose of this study was to investigate the concepts prevalent among students in physical science classes and to identify what classroom teachers would do when confronted with this knowledge. A 40-item, two-tiered instrument, Misconception Identification in Science Questionnaire (MISQ), was developed to identify certain concepts in the areas of force, heat, light, and electricity, and administered to 439 students. Six teachers were observed and interviewed to determine teacher opinion relative to test usefulness, diagnostic testing in general and other instructional factors. Analysis of teacher interviews revealed three uses of the MISQ instrument in this study. The first of these was in the form of a general informative

22.09 FRANKLIN CONTINUED

nature. The second utilized selected items as integral parts of the instructional process. The third used student responses as part of a grouping strategy. Further analysis reveals that the rather limited use of the MISQ may be due to several factors, both external and internal to the classroom.

22.09

TEACHING ABOUT MOLECULAR INTERACTIONS: THE ROLE OF PHYSICAL ANALOGUES AND HYPOTHETICO-DEDUCTIVE REASONING IN CONCEPTUAL CHANGE

Anton Lawson, William Baker, Lisa DiDonato, Michael Verdi and Margaret Johnson, Arizona State University

Students classified as intuitive, transitional or hypothetico-deductive reasoners were taught two theoretical concepts: Molecular polarity and bonding. These two theoretical concepts were used to explain the mixing of dye with water, but not with oil, when all three substances were shaken in a container. Students were then tested in a context in which they misapplied the concepts to explain the spread of dye in standing water. Next students were taught another theoretical concept (diffusion), with and without the use of physical analogues and were retested. The analogy group scored significantly higher than the control group on a question that required the definition of diffusion. Also, hypothetico-deductive reasoning skill was significantly related to correct application of the diffusion concept and to change from misapplication of the polarity and bonding concepts to correct application of the diffusion concept. The results support the hypotheses that physical analogues are helpful in theoretical concept acquisition and that hypothetico-deductive reasoning is needed for successful concept application and change.

22.09

LEARNING AND INSTRUCTION IN THE ORGANIC SYNTHESIS LABORATORY

Hanno van Keulen and Adri H. Verdonk, Utrecht University, The Netherlands

Purpose of this study was the construction of a content specific pedagogical theory with regard to learning and instruction in chemistry, especially in the field of organic synthesis. The study consisted of three parts: 1. A reflection on goals and structure of instruction in this field, leading to an new approach called simulation of research. 2. Development of an instrument for qualitative research which could provide insight into the relations between instruction and learning. 3. Application of this instrument to the new approach. As a result, three content specific concepts (the structure-activity concept, the reaction behavior concept, and the synthesis planning concept) for instruction and learning were developed. These concepts were useful in the development of new laboratory experiments in organic synthesis.

22.11

A MATHEMATICAL MODEL FOR AJZEN'S ATTITUDE THEORY

Piyush Swami and N. Rao Chekuri, University of Cincinnati

Mathematical model building is a well established practice in natural sciences and psychology. We have attempted to extend that practice to the Theory of Planned Behavior as proposed by Ajzen. This theory explains the interrelationships among behavioral beliefs, normative beliefs control beliefs, attitudes, subjective norms, behavioral intentions and behaviors. This paper attempts to elaborate on the basic ideas of this theory by providing it a mathematical basis so that further insights can be possible. The model will lead to conceptualize further research in a significantly different manner. A set of independent beliefs (β_i) i=i...n towards an act can be represented as a real valued n - dimensional vector space $B^{(n)}$and the corresponding set of consequences (η_i) i= 1....n. a real valued n-dimensional vector space $E^{(n)}$. An individual's belief values bi can be represented as a belief vector |b> in belief space $B^{(n)}$and the corresponding evaluation outcome values e_i as a consequence vector |e> in the consequence space $E^{(n)}$. Attitude (A) towards the act is a scalar product between |b>, and |e>.

22.11 SWAMI CONTINUED

The vector spaces $B^{(n)}$ and $E^{(n)}$ contain all the individuals' belief and evaluation outcome vectors respectively.

24.09

NUMBERS, TABLES & GRAPHS: THE MATHEMATIZATION OF EXPERIENCE BY GRADE 8 STUDENTS IN AN OPEN-INQUIRY LABORATORY ENVIRONMENT OR AN INTRODUCTION TO SCIENTIFIC PRACTICES OF REPRESENTATION

G. Michael Bowen, University of Guelph, and
Wolff-Michael Roth, Simon Fraser University

The purpose of this classroom study was to investigate the use of representations in three Grade 8 general sciences classes which engaged in a ten-week open-inquiry about the relationships between biological and physical features in the environment. A constructivist perspective was used to conceptualize and conduct the research project. The data sources included video- and audio-tapes of classrooms and interviews, the transcripts of these tapes, student produced artifacts, and the teachers' curriculum guides, field notes, and reflective journals. An interpretive method was used to construct assertions and the supporting data. In the setting provided, students increasingly used representations such as graphs and data tables to support their claims in a convincing manner; the use of abstract equations and percent calculations did not change over the course of the study. Representations also functioned as conscription devices which students constructed in real-time and through which they engaged each other in scientific discourse. Understanding representations as inscription and conscription devices focuses on the social aspects of knowing, which has important implications for teachers' conceptualization of learning and their organization of science classrooms.

24.09

INDOORS AND OUTDOORS: THE LOGIC OF FRAMING AND SOLVING PROBLEMS IN CONSTRAINED AND NATURALISTIC CONTEXTS

Wolff-Michael Roth, Simon Fraser University, and
G. Michael Bowen, University of Guelph

24.09 ROTH CONTINUED

This study of learning in a Grade 8 open-inquiry science classroom focused on students' (a) problem framing and solving as they engaged in field research and (b) problem solving on **contextual** word problems which we had constructed from the students' own inquiries. A constructivist epistemology served as framework for this interpretive study. The data sources included video-taped lessons, audio-taped interviews and teacher-student interactions, and the artifacts constructed by students and teacher-researchers in the course of the study. Our work documents and discusses the enormous work done by students in constructing research problems and resolving these problems through engaging in field research. During this field research, many local problems emerged in which students learned to resolve interactionally with their peers and the settings. The students' framing of problems for research and in the field setting stood in sharp contrast with their work on teacher-constructed, contextual word problems. These differences led us to a critical analysis of traditional word problems.

24.10

STUDENT EXPERIENCES IN COLLEGIATE GENERAL CHEMISTRY: EFFECTS ON ATTITUDE AND INTENTION TO MAJOR IN SCIENCE

Lee Meadows and Thomas R. Koballa, Jr., University of Georgia

Across the United States, the numbers of students achieving science-related majors is dropping, and general chemistry at the college level, a gateway to the science major, may be part of this problem. This research describes the affective evaluations given by students to their experiences in a general chemistry course sequence designed for science majors and how those affective evaluations influence their decisions about continuing their science majors. Due to its exploratory nature, this study will sample broadly. Sampling will occur in three types of classrooms: a large class taught by traditional lecture, a large class implementing study groups and integration of lab and lecture, and a small class structured according to cooperative learning. Sampling will target diverse students: Majority and minority

24.10 MEADOWS CONTINUED

students, males and females; students of traditional and non-traditional ages; and students of differing ability levels. The chief research techniques to be used are open- and close-ended questionnaires administered to all students, focus group interviews of small groups of students, and formal interviews of individual students. The close-ended questionnaires will follow the tenets of Ajzen and Fishbein's theory of planned behavior.

24.10

A LONGITUDINAL STUDY OF AMERICAN YOUTH: STUDENTS' ATTITUDES TOWARD SCIENCE, MATH, ENGLISH AND SOCIAL STUDIES

Rong Rong and Jianjun Wang, Kansas State University,
J. Steve Oliver, University of Georgia, and
Andrew T. Lumpe, University of Toledo

Middle school data from the Longitudinal Study of American Youth (LSAY) have been analyzed through the LISREL 6 software package. Two longitudinal patterns have been identified: (1) Among students' attitudes toward science, math, English and social studies, the correlation between English and social studies is consistently higher than the correlations between any other subjects; (2) The attitude toward science has the second highest correlation with the attitudes toward other subjects. The factor loadings on the attitudes indicate that the understanding of a subject has the largest contribution to the students' positive attitude toward the subject.

24.10

SYNTHESIS OF SCIENCE ATTITUDE RESEARCH FOR THE ELEMENTARY GRADES

Thomas R. Koballa, Jr., The University of Georgia

The study was historical in design, and involved interpretation. The goal was to describe the affective domain in science education, paying particular attention to science learning in the elementary grades. In this regard, attention was directed to two areas: The findings of science education research in the affective domain and new approaches for

24.10 KOBALLA CONTINUED

understanding how affect influences and is influenced by science-related behaviors. Attention was focussed on attitudes, since attitudes have been given far more attention by science educators than any other construct of the affective domain. The findings are clustered in three areas: (1) the origins of attitude research in science education, (2) results of attitude studies over the years, and (3) the influence of the cognitive revolution on attitude research in science education.

27.08

PEER COLLABORATION AND CONCEPT DEVELOPMENT

Andrew T. Lumpe, The University of Toledo, and
John R. Staver, Kansas State University

The researchers designed the study to achieve two goals: 1) determine the effect of a peer collaborative problem situation on high school biology students' acquisition of concepts related to plant nutrition; and 2) examine interactions in a collaborative peer group problem solving situation and determine how these interactions relate to the development of concepts associated with plant nutrition. Using quantitative and qualitative data analysis techniques, the researchers concluded that students working in peer collaborative groups developed more scientifically correct conceptions of plant nutrition than students working alone. Not all group generated concepts were internalized by group members when assessed individually. There exists a functional relationship between prior knowledge and concept development. Two types of peer interaction, consonant and dissonant, were identified as enhancing concept development. When peer group roles are not assigned, roles fluctuate depending on group members' expertise or perceived expertise displaying a bi-directional zone of proximal development. This zone allows for enhanced concept development. Based on the above conclusions, the researchers recommend: 1) peer collaboration be used to help students overcome scientific misconceptions; 2) peer collaborative tasks be designed to engage students in consonant and dissonant interactions; 3) cognitive group roles, as opposed to traditional managerial cooperative group roles, be used.

27.08

THE IMPORTANCE OF HETEROGENEOUS GROUPING AS AN ELEMENT OF COOPERATIVE LEARNING FOR ELEMENTARY EDUCATION MAJORS IN AN INTRODUCTORY LIFE SCIENCE COURSE

Scott B. Watson, East Carolina University

The purpose of this study was to clarify the importance of heterogeneous grouping as an element of cooperative learning. A pretest-posttest control group design was utilized for this study. The independent variable was the method of arranging groups (heterogeneously or homogeneously). Dependent variables were scores from the NABT/NSTA Biology Exam (1987). Students were also administered a questionnaire in order to determine their perceptions of their cooperative learning situation. An analysis of covariance (ANCOVA) was used as the data analysis procedure for the experimental portion of the study. No significant differences in achievement were found between the two treatment conditions. Results from the student perceptions questionnaires did reveal substantial differences between students in the two treatment conditions, with generally more positive responses give by students in the homogeneous condition.

28.03

COLLABORATIVE PROCESSES OF KNOWLEDGE CONSTRUCTION IN SCIENCE TEACHING AND LEARNING

Deborah Tippins, University of Georgia,
Kenneth Tobin, Florida State University, and
Karl Hook, Florida High School, Tallahassee

Knowledge is produced in the classroom through the interaction of student experience and information derived from the disciplines. The point where the information of the disciplines interacts with the understandings and experience students carry with them to school is the **zone** where knowledge is created. The current study, which is part of a larger research effort focused on middle school science teaching and learning, addresses 1) the manner in which individuals attempt to make sense of science phenomena, and 2) the mediational role of the teacher in relation to students negotiating the meaning of

28.03 TIPPINS CONTINUED

science concepts and arriving at consensus. An analysis of task, interaction, and knowledge domains provides a framework for making sense of collaborative processes of knowledge construction.

GENDER AND EQUITY

5.03

TEMPLATE FOR A GENDER-EQUITABLE SCIENCE PROGRAM

Jacqueline A. Hykle, University of Cincinnati

The purpose of this study was to develop a template or model for a gender-equitable elementary or secondary science program based upon an extensive review of research on educational factors which might influence girls' and women's choices of science as a field of study and as a career. This program takes into consideration the cumulative effect of the many types of educational influences identified by the research community as being influential. Its function is to provide a comprehensive, research-based framework which can be used as a springboard for designing future research that acknowledges and considers the interrelated complexity of these influences.

5.03

CURRICULUM REFORM AND GENDER-FAIR ASSESSMENT

Lesley H. Parker, and Leonie J. Rennie, Curtin University

This paper reports a study of teacher implementation of assessment strategies associated with major revisions to a high school physics curriculum. The revisions were aimed at a more contextually-based approach to the teaching and learning of physics and at making the curriculum more gender-inclusive. The aim of the research was to study the processes involved in operationalizing assessment strategies and tasks which were consistent with the new approach. Specifically, the paper focuses on the implementation of gender-fair assessment at the classroom level, with particular reference to the context and format of assessment tasks. It describes the process through which teachers and researchers worked jointly to refine their skills and knowledge in relation to assessment, and to translate this knowledge and skills base into classroom reality.

5.03

A COMPARATIVE STUDY BETWEEN THE U.S. AND CHINA: SCHOOL EQUITY IN SCIENCE EDUCATION

Jianjun Wang, and John R. Staver, Kansas State University

Ninth grade data sets from the Second IEA Science Study (SISS) in the U.S. and the SISS Extension Study (SES) in China were analyzed to compare school equity in science education between the two countries. Three questions are addressed in this paper: (1) How can school equity be evaluated in science education based on the two surveys? (2) What was the status of the school equity in the U.S. in 1986 and in China in 1988? (3) Based on the comparison, what are factors for explaining the difference between the two countries?

5.15

DIFFERENTIAL SOCIALIZATION IN MATH/SCIENCE ACHIEVEMENT VIEWED FROM CROSS-NATIONAL/CROSS-CULTURAL PARENTAL PERSPECTIVES

James R. Campbell, Jeffrey Beaudry, John Spiridakis,
Rosemary Cipriani-Sklar, St. John's University,
Rosalind J. Wu, Taiwan Provincial Institute,
Pella Calogiannakis-Hourdakis, George Flouris, University of Crete, Rethymno, Greece,
Manfred P. Herbig, Jetta Scheithauer, Institut fur Padagogik, Ruhr University, Germany,
Ruth Zuzovsky, Tel Aviv University,
Pinchas Tamir, Hebrew University, and
Somwung Pitiyanuwat, Chulalongkorn University

The objectives of the studies within this paper set were to determine the causal links related to the math or science achievement of fifth- and sixth-grade children in six countries (Republic of China, Greece, Germany, Israel, Thailand and the U.S.A.). Within each of these countries how much of the children's math or science achievement is related to parental influence? Does parental influence differ for boys and girls? Are academically-talented daughters treated differently than boys in each country? Does the educational level of the parents have an effect on achievement? How are these variables interrelated with such family processes as parental pressure, psychological support, parental help, press, for intellectual development and parental monitoring? How

5.15 CAMPBELL CONTINUED

do the children's math-or science self-concepts connect with these variables? Finally, how do all of these variables interact and eventually fit into the differential socialization paradigm that Campbell has developed to explain the gender inequities that currently exist in the technical fields. Do these inequities exist in all six countries? This paper set will examine the gender differences across the six countries, and within four distinct cultures in the U.S..

7.11

CULTURALLY SYNTONIC VARIABLES IN THE BILINGUAL/BICULTURAL SCIENCE CLASSROOM

Robertta H. Barba, San Diego State University

The purpose of this study was determine if existing bilingual/bicultural elementary science instructional environments address the educational needs of Hispanic/Latino children. This study examined 57 randomly selected elementary bilingual/bicultural science classrooms in a large metropolitan area of the southwestern United States in terms of culturally syntonic (i.e. culture-of-origin beliefs, attitudes, and/or practices which influence both positively and negatively, functionally and dysfunctionally the teaching/learning process) or culturally harmonious variables. Findings from this study indicate that Hispanic/Latino children are receiving science instruction with culturally asyntonic teaching strategies, instructional language, and curriculum materials.

7.11

NARST SYMPOSIUM ON DIVERSITY AND SCIENCE TEACHING AND LEARNING

Alejandro J. Gallard, Florida State University

As the student population of the United States is changing, the notion of diversity is becoming more critical in the teaching and learning of science. For example, today diversity encompasses such complex issues as the teaching and learning needs of females and minorities of color, language, and people of low social economic status. These categories are representative of people who have the highest dropout

7.11 GALLARD CONTINUED

rates, and the lowest representation in the sciences. In this symposium we will look at diversity from four different research perspectives: Culture, equity, gender and language. These four areas of scholarship encompass critical issues in our kindergarten through university science classrooms, and teacher preparation programs.

7.11

SCIENCE TEACHING AND LEARNING: GENDER IS STILL AN ISSUE

Cheryl L. Mason, San Diego State University

Females, especially those of color, are clearly underrepresented in the scientific and technological work force. It is time to seriously address the needs of this population, especially since the projected figures indicate that racial and ethnic groups in the United States will soon no longer be in the minority, but will outnumber Anglos. Studies involving student attitudes toward science and scientists have shown that a major factor in attitude formation and/or change is the classroom learning environment. Girls are especially sensitive to stereotypic environments that perpetuate science as being a white male domain. Coming from different ethnic and cultural backgrounds, girls often are faced with the triple plight of being female, being a person of color and having a limited proficiency of English. Although it is known that students with a language barrier become more proficient in an environment with hands-on, minds-on activities, this study indicates that this is not often the case. Despite the pervasiveness of societal sex-role and ethnic/racial stereotyping, classroom environments can have an ameliorating effect on student attitudes and achievement levels by nurturing students' interests in science and by augmenting confidence in their ability to do science.

7.11

NEW VOICE FOR FEMALE ELEMENTARY TEACHERS IN SCIENCE

Sharon Parsons, Catherine DeLauter, and Blanca De La Torre, San José State University

7.11 PARSONS CONTINUED

Whenever the issue of inadequate instruction in science is discussed elementary teachers receive a major portion of the criticism and this has added to elementary teachers viewing themselves as deficient. Since the majority of elementary teachers are female we need to reconsider this issue. An alternate vision would be the viewing of the science education of women as being deficient. Such a position calls for a different approach in teaching females enrolled in preservice elementary science education. One approach is to offer a different view of scientific knowledge which involves preservice teachers in understanding the nature of the construction of scientific knowledge and the envisioning of themselves in such roles as teacher as researcher, and teacher as experienced learner. By giving preservice teachers the opportunity to view the construction of scientific knowledge differently it allows an opportunity for a voice. In this case study we will describe the stories of three women(two preservice teachers and a science educator) involved in preservice education who are beginning to construct a new framework for elementary science education.

7.11

A U.S. TEACHER'S NARRATIVE AND THE EXPERIENCES OF AN IRANIAN TEENAGE REFUGEE AND ENHANCING UNDERSTANDING IN THE SCIENCE CLASSROOM

Benita C. Wiggins, Godby High School, Tallahassee,
Florida.

The teacher/researcher became dissatisfied with her own lack of understanding of the refugee experience, the impact of culture on schooling, and her preparedness for the teaching and learning of refugee students in science. The voice of **Mylamb**, a female Iranian refugee student, was used to gain insights which have implications for the preparation of science teachers who can meet the culturally diverse learning needs of refugee students. An eight month written dialogue journal exchange, self-reflection, document analysis, autobiography portrayal, vignettes, and narrative were used to better understand the implications of the study for personal teaching practice.

12.14

MASCULINITY, FEMININITY AND ANDROGYNY AMONG ACADEMIC WOMEN SCIENTISTS

Carolyn Butcher Dickman, Radford University

Tho study involved 86 female academic scientist who participated in a self-administered Bem Sex-Role Inventory (BSRI). The results show that more women scored in the Masculine and Androgenous categories than in the Feminine and Undifferentiated categories (36.05% masculine, 30.23% androgenous, 18.6O% undifferentiated, and 15.12% feminine). A frequency distribution of the classifications on tho BSRI across age categories also revealed that most women within the androgenous category fell between 40 and 49 years of age. The majority of women categorized as feminine were over 45 years of age while the largest percentage of respondents classed as masculine were 49 and younger. The scores in the undifferentiated group did not fall into any apparent pattern across age groups. Androgynous participants expressed more comfort when interacting with their female students and expressed more positive attitudes toward females studying science and engaging in scientifically oriented career than did members of the other three groups. Older women scientists in academia appeared to adapt to their masculine oriented careers differently then did the younger ones.

12.14

CAN THE HIDDEN CURRICULUM CONCEPT INFORM OUR UNDERSTANDING OF GENDER DIFFERENCES IN SCIENCE CAREER CHOICE?

Scott F. Marion, The University of Maine

While recent studies and reports have identified hidden curriculum sources (either implicitly or explicitly) contributing to gender differences in college majors, few writers, other than Martin (1989) have discussed the usefulness of the hidden curriculum concept for explaining these gender differences. This study uses Martin's conceptual framework of "hidden curriculum" and the results of recent investigations to examine the utility of this concept in explaining the underrepresentation of women in science. What has been learned about the effects of a hidden curriculum in science education through these studies? The most powerful sources uncovered through this study

12.14 MARION CONTINUED

relate to the influence of certain systematic learning states on the selection of undergraduate science majors. However, there needs to be more work by theorists and philosophers to help clarify the hidden curriculum concept, especially if it is to guide empirical investigations. Part of the difficulty in relating the results of any empirical study to the hidden curriculum concept is due to the elusive nature of the concept itself. Implications for science education are discussed.

13.03

PERCEPTIONS OF SCIENCE EDUCATION AND ATTITUDES TOWARD SCIENCE OF AFRICAN STUDENTS

N. K. Appiah, University of Georgia

This study was designed to determine African students' perceptions of their pre-college science education programs in Africa and their attitudes toward science. It was also intended to find out if there was a relationship between the students' perceptions of their science education programs and their attitudes toward science. The study was conducted partly as a survey and partly as an interview with male and female students from both English and French speaking African countries. Findings that show significant relationship between the students' perceptions and their attitudes are discussed. Differences and similarities in the responses between male and female students and between students from both English and French speaking African countries are also discussed.

13.03

THE EFFECT OF INQUIRY ACTIVITIES ON GENDER AND RACIAL DIFFERENCES IN ELEMENTARY STUDENTS' INTERESTS, ENJOYMENT, AND CONFIDENCE IN

Arta Damnjanovic, and Jane Butler Kahle, Miami University, Oxford, Ohio

The objectives for this study were to: 1) investigate African-American and Caucasian fourth and fifth grade students' interest in performing activities with electricity, 2) measure students' enjoyment of electricity topics following participation

13.03 DAMNJANOVIC CONTINUED

in classes taught using inquiry activities, 3) investigate if inquiry electricity activities helped African-American and Caucasian females acquire more positive attitudes toward science, and 4) investigate students' self-concepts and career interests after participation in inquiry activities. All responses were compared by sex and race. Prior to the inquiry lessons, boys of both racial groups had greater overall interest in the topic of electricity than did either African-American or Caucasian girls. Use of inquiry activities increased both African-American and Caucasian females enjoyment of electricity topics, thus, decreasing differences between boys and girls. Furthermore, after participating in inquiry activities, all students indicated equally high interest in a career as an electricians. However, both African-American and Caucasian boys maintained highly sexist views of girls' abilities regardless of the more active part of females in the science activities. In addition, Caucasian girls expressed less self-confidence in their science abilities than did African-American girls or boys in both racial groups.

15.03

MINORITIES AND SCIENCE EDUCATION: A QUALITATIVE ANALYSIS OF MIDDLE SCHOOL SCIENCE

Mary Antony, University of Michigan

This ethnographic study focuses on the school's contribution to inequalities in science education. The purpose was to understand how the school experiences of students within the same school and within the same classroom differed by race. Five science classes of an urban middle school in the midwest, having an enrollment of approximately 40 percent African American, were observed for four months. Teachers, councilors and students were interviewed. Preliminary observations suggest that differential outcomes of African America students can be related to the different experiences they undergo in the school. They tend to be disproportionately placed in non academic programs where they learn little science. Teachers tend to reinforce social rather than academic skills. These students get little guidance in taking the right courses that would help them achieve their

15.03 ANTONY CONTINUED

aspirations. It appears that schools in attempting to accommodate for differences in student background actually limit their opportunity to learn.

15.03

WHEN GIRLS TALK: AN EXAMINATION OF HIGH SCHOOL PHYSICS CLASSES

Vicka Corey, University of Washington,
Emily Van Zee, University of California at Berkeley, and
James Mistrell, Dorothy Simpson, Virginia Stimpson,
Mercer Island High School

Much recent literature has discussed girls' lack of representation in classroom dialogue, especially in the higher grades and in science classes. However, our observations of high-school physics classes using a method of constructivist, cognitively based instruction have revealed that in a significant number of these classes, girls actually do speak up -- at levels meeting or exceeding the participation of their male classmates. Discourse patterns within these classes are analyzed, as is subject-matter learning as assessed by pre- and post-instructional testing. Various factors affecting these classes are discussed, including the class's consensual epistemology of science and rules of discourse, as well as the individual girls' personal epistemologies and styles of speaking.

15.03

EDUCATIONAL HISTORIES OF A SELECTED GROUP OF POST-DOCTORAL FEMALE ACADEMIC BIOLOGISTS

Anne-Marie Scholer, Boston University

The education and career experiences of practicing female academic biologists were studied, as a response to disproportionate attrition of women from college, doctoral and post-doctoral science. The subjects were interviewed, and the transcripts coded to discover common aids to their success. The subjects are at three different stages: First appointment, up for tenure, and fully established. This breakdown provides different perspectives of the training process.

20.03

THE INFLUENCE AND RETENTION OF CULTURALLY-ORIENTED SCIENCE TEACHING PRINCIPLES AMONG TEACHERS OF INDIGENOUS AMERICAN CHILDREN

Gerry D. Haukoos, Illinois State University

Through the years, literature has made little reference to applying teacher behavior principles to teachers and students with non-European American ancestry. It has been presumed that since science is acultural, teachers and children of all cultures will respond equally well to the same activities and instructional stimuli. This study investigated the effectiveness of culturally-oriented science training for in-service teachers of indigenous American children. Initial training results indicated teachers made significant gains in adapting (a) integration of science and cultural strategies, and (b) hands-on/student-centered teaching strategies. At the same time, there were parallel declines in content/teacher-centered strategies. One year later, teachers continued to maintain teacher behavior which applied culturally-oriented instruction. However, significant shifts back to original values were reported for hands-on/student-center strategies and content/teacher-centered strategies.

20.03

SCIENCE TEACHER DECISION-MAKING IN CLASSROOMS WITH CULTURAL DIVERSITY

J. Randy McGinnis, University of Georgia
Suzanne Best, and Cary Sell, World Middle School

This study investigated the before-, during-, and after-teaching decision-making practices of two teachers who taught culturally diverse students. Participants included a white female veteran life science teacher and a first-year white male earth science teacher and their students in a southeastern middle school. Data were obtained through standard qualitative techniques, analyzed through analytic induction, the constant comparison method, and semiology, and presented in case study format. Key findings were that the teachers' shared the belief of not acknowledging their students' cultural diversity in their science lessons, that most teacher actions included no

20.03 MCGINNIS CONTINUED

alternative choices, and that the teachers filtered their pedagogical decisions through a **fair play** rule of conduct defined as social justice based on equality instead of equity. Teacher actions that had no identified alternatives were termed ritual-instructor action-practices and provided insight into the mores of teaching the teachers held. The researcher interpreted the school's communication code as a Code of Contradiction: The students' culturally diversity in the social sphere was extolled; in the academic sphere, it was avoided.

20.03

AN EXAMINATION OF THE SCIENCE LITERACY OF SCIENTISTS AND SCIENCE EDUCATORS

Dennis Showers, The State University of New York at Geneseo

This paper describes a project involving the collaboration between the University of Nebraska, Lincoln and the administration and science teachers of the Omaha (Nebraska) public schools. The goals of this project are to improve the learning environments in multicultural science classrooms by assisting teachers in reconstructing their curriculum and reconceptualizing their teaching practices to be culturally relevant for all students, including minorities, the economically deprived, and females. Summer workshops and academic year components are described that emphasize the following: Teachers must be at the heart of curricular change as they construct personalized visions of teaching science within the cultural context of their schools. Teacher enhancement depends on facilitating teacher reflection on their beliefs and practices. Reflective practice and action research symbolize important changes in our ways of thinking concerning teaching and curricular reform. Reflection and action research imply that teachers must collaborate, interact, and communicate about classroom interactions, instructional strategies, and the relationships between school culture and power. Resulting culturally relevant curriculum developments and instructional strategies are continually being field tested in this school district and are available on a data base for all teachers.

24.03

ATTITUDES OF PRE-SERVICE ELEMENTARY SCHOOL TEACHERS TOWARD MALES AND FEMALES IN BIOLOGY CLASSES

Eileen D. Bunderson, and J. Hugh Baird, Brigham
Young University

Teachers play a significant role in discouraging or attracting girls to the study of science. Research was initiated during the winter of 1991-92 to measure attitudes of pre-service elementary teachers toward males and females in biology classes. A modified Likert scale was developed and administered to female junior and senior elementary education majors enrolled in a science methods course at Brigham Young University, Rhode Island College and the University of New Mexico. Data indicate substantial differences in how the respondents view science/science activities for males and females. Females continue to be viewed as being less well-suited for careers in science, less able in the laboratory, and less logical, creative or curious about science topics than males.

24.03

A COMPARISON OF GENDER PORTRAYAL IN THE ILLUSTRATIONS OF THE SEVEN MOST COMMONLY USED HIGH SCHOOL BIOLOGY TEXTBOOKS

Douglas Rosendahl, Winona Middle School, and D. Daryl Adams,
Mankato State University

This study compared illustrations in the recent editions of the seven most commonly used high school biology textbooks in terms of gender fairness. Five gender factors 1) number of males and females in the illustrations, 2) frequency of figures portrayed in traditional and nontraditional gender roles, 3) frequency of figures pictured in active and passive roles, 4) sex of the dominant human figure in the illustration, and 5) frequency of scientists shown as male or female were used to determine gender fairness. Data for each gender factor were collected from each textbook. Data for each factor were subjected to Chi-square analysis. Results from the data analysis indicated that the seven textbooks varied in gender fairness for the five gender factors. The greatest variation was for two gender factors: 1) traditional and nontraditional roles, and 2) active and passive gender roles. Results also showed that the best ranked textbook

24.03 ROSENDAHL CONTINUED

was gender fair for eight of nine criteria and that the worst ranked textbook was gender fair for one of nine criteria. This study raises the awareness of the issue of gender fairness in textbooks and provides a valuable tool that could be used to evaluate textbooks and other material that contain illustrations or depictions of human figures.

27.03

THE MORAL CONTENT OF SCIENCE METHODS TEXTBOOKS

Craig Kesselheim, University of Maine

It is the purpose of this paper to describe and analyze the **moral content** of five preservice **methods** textbooks. Five recently published textbooks, taken from both elementary and secondary levels, were examined in those sections which addressed either: a) moral education and b) teaching in controversial topics. The paper reports on the degrees of **moral avoidance** or **moral confrontation** to be found in a selection of sources. Implications of this analysis for science methods teachers are discussed. Finally, a request for suggestions for analysis protocol is made to those who wish to pursue textbook **moral content**.

28.07

CAN WE MAKE SCIENCE GENDER-INCLUSIVE?: RECENT FINDINGS, THOUGHTS AND CONCERNS

Anita Roychoudbury, Miami University,
Dale Baker, Arizona State University, and
Leonie J. Rennie, Curtin University

In this symposium we will present girls' views on science, science careers, and other related factors. Interviews of girls from various grade levels manifest the importance of the affective and affiliative needs of the girls in learning science and choosing a scientific career. Then we will present suggestions for modifications of science curricula and teaching for bringing girls into science. We will propose a change in the epistemological premise of science from an objectivist to a constructivist one. Finally, experiences of science educators from the

28.07 ROYCHOUDBURY CONTINUED

implementation of a gender-inclusive curriculum in Western Australia will be discussed.

HISTORY, PHILOSOPHY, AND EPISTEMOLOGY

1.02

HISTORY, PHILOSOPHY, AND SCIENCE TEACHING: RECENT RESEARCH PUBLISHED IN THE JOURNAL SCIENCE & EDUCATION

Michael R. Matthews, Education Department, University of Auckland

The journal Science & Education is associated with the International History, Philosophy, and Science Teaching Group. Six numbers have been published dealing with **Contributions to Science and Mathematics Education from History, Philosophy and Sociology of Science**. This poster session will tabulate the 35 or so articles that have been published, and indicate the theoretical and practical concerns of science education to which studies in the history, philosophy, and sociology of science have contributed. The possible justifications for including courses in history and philosophy of science in science teacher education programmes will be canvassed. And attention will be paid to ways in which studies in history and philosophy can provide a bridge between science and mathematics education. The session will also outline something of the activities of the International History, Philosophy, and Science Teaching Group.

1.04

PEDAGOGICAL KNOWLEDGE STRUCTURES OF PROSPECTIVE SCIENCE AND MATHEMATICS TEACHERS: RELATIONSHIPS TO PERFORMANCE IN TEACHING METHODOLOGY COURSE

Teresa M. Kokoski, University of New Mexico, and
Lynn Dale Housner, New Mexico State University

This study examined the structure of pedagogical knowledge housed in the memory of experienced teacher educators and the influence of this knowledge on changes in the pedagogical knowledge structures of prospective teachers enrolled in science and mathematics teaching methods courses. More specifically, the study sought to examine the correlation between measures of student knowledge structures and course performance variables. Three different methods courses from three different institutions participated in the study. The investigation used Pathfinder network scaling algorithm, an associative networking technique to map the knowledge of both prospective students and

1.04 KOKOSKI CONTINUED

teacher educators and then looked at comparisons within and across students and teacher educators. The findings suggest there is some evidence for relating student success in course studies to changes in student pedagogical knowledge based on the teacher educator structure. Also, this provides a strategy for documenting the knowledge structures of students and how it changes over time.

7.03

STRESS ON THE ROLE OF EVIDENCE AS A BASIS OF KNOWLEDGE CLAIMS IN SCIENCE AND CONTROL BELIEFS IN ELEMENTARY SCHOOL CHILDREN

John Butler, Anchorage School District

The purpose of the study was to detect any gains in internality of control beliefs of elementary school children, their intention to act to resolve problems and their use of evidence as a basis of knowledge claims in science. Twelve classes were assigned to three groups: Text-lecture-recitation, hands-on, or hands-on with emphasis on evidence as the basis of knowledge in science. The students participated in 42 science lessons over a fifteen week period. Measurements were a paper and pencil pretest-posttest, pretest-posttest probing interviews and direct objective observations. Students may espouse use of evidence but often rely on teacher statements or prior knowledge in forming beliefs.

12.02

WORLD VIEW, METAPHYSICS, AND EPISTEMOLOGY

William W. Cobern, Arizona State University

It has been argued from world view theory that fundamental beliefs about the world exert a powerful influence on how sense is made of events in the world. However, the nature of that influence has remained enigmatic. Hannah Arendt's distinction between thinking and comprehension and knowing and apprehension provides a clarification. Thinking is the epistemological path to conceptual comprehension. Knowing is the metaphysical path to apprehension - to the acceptance of a concept as true or valid. Comprehension does not necessitate

12.02 COBERN CONTINUED

apprehension. One may reject a fully understood concept. The recent discussion in science education about world view is essentially a discussion about metaphysics. The importance to educational practice is this: Science educators are often at a loss to understand why some students fail to develop orthodox scientific conceptions even after the best of instruction. The argument from world view is that in some cases, it is not that the students fail to understand what is being taught (comprehension), they simply do not believe (apprehension). Thus, there are occasions when the careful epistemological explication of a concept is not sufficient to bring about learning. Instruction must also include a discussion of the metaphysical foundations that support epistemology.

12.02

THE MEANING OF THE LIVED EXPERIENCE OF BEING CHALLENGED

Mark J. Volkmann and William C. Kyle, Jr., Purdue University

Hermeneutic phenomenology provided the theoretical perspective to build an understanding of the internal meaning structure of the lived experience of being challenged (van Manen, 1990). The participant is a science teacher-leader engaged in the National Science Teachers Association Scope, Sequence, and Coordination (SS&C) project. My interpretation of his personal stories enabled me to construct an understanding of the experience of what it means to be challenged. I found that the structure of this experience involves making connections between pivotal lived experiences and decisions of how to teach. Understanding what it means to be challenged has implications for those who seek to understand teacher-leaders.

12.10

CONTRIBUTIONS FROM THE HISTORY AND PHILOSOPHY OF SCIENCE TO THE QUESTION OF MULTICULTURALISM IN SCIENCE EDUCATION

Nancy W. Brickhouse and William B. Stanley, University of Delaware,
Ronald Good, Louisiana State University,
Skip Hills, Queens University,
Michael Matthews, University of Aukland, and
Deborah Pomeroy, Harvard Graduate School of Education

12.10 BRICKHOUSE CONTINUED

This symposium will provide an overview of work being produced in the history and philosophy of science in science education and engage the audience in some of the debates in multicultural science education. Scholarship in the history and philosophy of science in science education has become important as science educators have attempted to come to grips with a variety of educational problems. Some educators have questioned whether the curriculum is overly concerned with transmitting the ideas of a white, male, middle class society and raise questions such as: Whose knowledge are we teaching? Who benefits and who loses by existing approaches to the curriculum? Until recently, science education has been largely untouched by these debates. It has been assumed that science is universal. This claim and the classroom implications for a variety of responses to it will be discussed.

13.02

HOW DOES BIOLOGICAL KNOWLEDGE **REALLY** GROW: A STUDY OF NOVICE AND EXPERT LIFE SCIENTISTS' RESEARCH PRACTICES USING LAUDAN'S TRIADIC NETWORK MODEL

Eleanor Abrams, Louisiana Sea Grant
James H. Wandersee, Louisiana State University

In his influential book entitled Restructuring Science Education: The Importance of Theories and Their Development (1990), Richard A. Duschl presents an equiposed triadic model of the growth of scientific knowledge which is based upon the work of philosopher Larry Laudan (1984). Stage One of our study tested that model against the research practices of 10 accomplished life scientists employed at a Carnegie Research I University--via purposive sampling, a carefully sequenced model-based interview schedule, face-to-face questioning, and propositional analysis of the interview transcripts. In Stage Two, a revised research-based graphic version of Laudan's model was presented to two experts on the nature of science during an extended interview. From that interview, further data collection and analysis, and an extensive literature search, our Stage One graphic was elaborated. In response to the interview, five novice graduate students and five advanced graduate students or new Ph.Ds of the original 10 life scientists were interviewed, using the same methods, to ascertain if

13.02 ABRAMS CONTINUED

their research perceptions and practices will differ from that of their mentors. Three implications for the teaching of biological science were derived from the research findings.

13.02

THEORY AND DATA IN A 7TH GRADE SCIENCE CLASSROOM

Maria Varelas and Joseph Becker, University of Illinois at Chicago

The problematics of science education are examined theoretically and empirically. A conceptual framework is developed centering around the theory-data dialectic of scientific activity and the top-down--bottom-up dialectic of education. The theory-data dialectic is specified as including both the inductive and deductive directions. Dialogue and argumentation (discourse) are seen as central to both the activity of science and the educative process, and hence, as the bridge between them. Discourse and written work of 7th grade students over a series of lessons in the Sink and Float unit were analyzed. A qualitative, interpretive methodology was used. It was found that the students experienced difficulty with the deductive direction of scientific activity. The students found it particularly difficult to develop the' necessary links between concepts and ideas in the theory level. In their two attempts to develop a question for experiment, most of the students produced a question which was less explicit and more vague than their own summaries of the theory. The students did succeed in establishing the integrity of their data. The students discussed the trustworthiness of their data in terms of reproducibility and accuracy. However, reference to the fit between theory and data was rare.

13.02

CREATING SOCIAL CONTEXTS THAT ENCOURAGE STUDENTS' SCIENTIFIC ARGUMENTS

R. Paul Vellom, Charles W. Anderson, Michigan State University, and Annemarie S. Palincsar, University of Michigan

This study investigates how middle school science students negotiate issues of power and meaning in collaborative working groups in a multicultural urban classroom. Given problems of a complex and

13.02 VELLOM CONTINUED

open-ended nature, the students are challenged to establish group positions or responses to the problems posed. This study examines how groups of students, and individuals within groups, come to understand a number of science concepts (having to do with the kinetic molecular theory), and how their understanding relates to the ongoing bargaining process surrounding roles within each group. Students who were active in group negotiations also tended to develop deeper and more meaningful understandings of the concepts, while less active students displayed a more limited understanding, characterized by their ritualized use of scientific language. The kinds of arguments that occurred were constrained by social ideas about when it was or was not **fair** or **polite** to challenge another group member. Even when the existence of different ideas or opinions was acknowledged by the students, the **best** argument did not necessarily win. The groups that we examined each established their own, unique patterns of interacting. Groups seemed to seek a situation not where power and status were equal, but where all students were satisfied that it was **fair**.

13.11

SEARCH FOR NEURO-COGNITIVE MODELS TO GUIDE RESEARCH IN SCIENCE EDUCATION

Rita W. Peterson, University of California, Irvine

The purpose of this study was (1) to identify the major advances that resulted from brain-mind research during the past decade; and (2) to evaluate neuro-cognitive models that might contribute to future science education research. An analysis of research documents published between 1982 and 1992 reveals that the gap between neuro-cognitive science and education has narrowed considerably, providing new information about the relationship between children's brain-mind development and their school success. From these findings which are summarized in a 20-page report, four promising conceptual models from the neuro-cognitive sciences were analyzed and evaluated based on discussions with their authors and site visits to their research laboratories: Bernstein, developmental neuropsychology, The

13.11 PETERSON CONTINUED

Boston Children's Hospital • Levine, neurodevelopmental variation, Child Development Research Institute, University of North Carolina • Languis, brain mapping- intervention, Brain- Behavior Lab, Ohio State University • and Squire, multiple memory systems, University of California, San Diego. Each of these models seeks to explain variations in human neuro- cognitive functioning. The results of this study highlights the potential value of neuro-cognitive models for understanding and predicting variations in students' science classroom performance, and bodes well for science educators during the 1990's Decade of the Brain.

20.02

A SOCIAL RECONSTRUCTIONIST VIEWPOINT ON THE HISTORY OF EARTH AND SPACE SCIENCES

Robertta H. Barba, San Diego State University

Traditionally, earth and space sciences have been taught in American schools from a Eurocentric and/or androcentric viewpoint. In the past, emphasis in earth and space science curricula in schools has been placed on the **scientific method** and on **famous men of science**. This view of the history of earth and space sciences excludes the contributions of many culturally diverse individuals and groups from history (Pearson & Bechtel, 1989) and deprives children of vitally needed role models. One goal of science education, including earth and space science education, as expressed in The Liberal Art of Science, is **to increase the numbers of women, Blacks, and Hispanics who major in natural sciences and pursue science and science-related careers** (MAS, 1990, p. 64). Actualization of this goal will require that culturally diverse children be involved in learning and doing science. This paper seeks to examine the historical, axiological and epistemological roots of earth and space sciences as they are presented in currently used earth science textbooks in American public schools and to propose a culturally transforming model for incorporation into those materials.

20.02

USING INSTRUCTIONAL FRAMEWORKS TO INCORPORATE HISTORY AND PHILOSOPHY OF SCIENCE INTO EARTH SCIENCE EDUCATION

Michael J. Smith, The University of Pittsburgh

The presentation will focus upon the application of two instructional frameworks to the design of a curriculum unit on the history of development of theories for the earth's interior structure. The two frameworks used are testing and evaluating scientific theories through arguments and the instructional framework for incorporating the history and nature of science and technology into science education developed jointly by BSCS and SSEC. The proposed curriculum places the evaluation of six historical models for the earth's interior structure that have been proposed over the past 300 years as the focal point of instruction. It includes individual, collaborative, and classroom activities centered around the evaluation and debate of the dynamic roles which evidence, technology, and aims of research have played in the development of scientific models. It offers opportunities for related laboratory and research work, classroom dialogue and presentation, and the construction of multiple models so as to foster conceptual change and meaningful understanding of the goals and products of scientific endeavor.

20.11

RELATIONS BETWEEN SECONDARY SCHOOL STUDENTS' EPISTEMOLOGICAL BELIEFS, MOTIVATIONAL PATTERNS AND CONCEPTUAL CHANGE: A REVIEW OF RESEARCH

Gaoyin Qian, The University of Georgia

This literature review was conducted by incorporating two motivational aspects: Epistemological beliefs and motivational patterns, in a theoretical model proposed by Dweck and Leggett (1988). The review exposed a need for future research to investigate the effects of refutational expository text, epistemological beliefs and learned helplessness on secondary school students' learning counterintuitive science concepts in an integrated way. This conclusion is based on the finding that results of refutational expository text are inconclusive from the review of eight major studies conducted by researchers in

20.11 QIAN CONTINUED

reading and science education among secondary school students. The review also found that studies that have examined epistemological beliefs have generally involved undergraduate students. There is still uncertainty about the relation between epistemological beliefs and students' performances on learning science concepts from text. Research that has explored the effects of learned helplessness has primarily involved elementary school students by incorporating highly contrived learning materials in a laboratory setting. Learning from content areas has been overlooked in the study of learned helplessness. Future research is needed to verify the Dweck and Leggett theoretical model by incorporating epistemological beliefs, motivational patterns, and conceptual change.

22.02

CHANGES IN THE UNDERSTANDING OF THE NATURE OF SCIENCE IN URBAN HIGH SCHOOL TEACHERS AFTER AN INTENSE, THREE-WEEK LONG SUMMER INSTITUTE

Thomas Lord, and Terry Peard, Indiana University of Pennsylvania

Twenty urban secondary school science teachers were involved in an intensive three-week long summer institute at a mid size Pennsylvania university. During the day, the participants worked with experienced scientists on research projects on and off campus. In the evenings, the teachers met with professors of science education to discuss classroom implementation of what they had experienced during the day. On the initial day of the institute, participants were administered a series of tests to measure their attitudes and understanding of the nature of science. The test series was again given at the conclusion of the project. This pre/post assessment indicated that a shift in teachers' views on some aspects of the nature of science had occurred. The study, therefore, suggests that short, intense inservice workshops conducted over the summer can affect secondary school teachers perceptions and understanding of the nature of science.

22.02

THE ROLE OF TEACHERS' EPISTEMOLOGIES IN FACILITATING HIGHER-LEVEL THINKING USING A COMPUTERIZED SCIENTIFIC DATABASE

Dorit Maor and Peter Taylor, National Key Centre for School Science and Mathematics, Curtin University of Technology, Australia

The purpose of this session is to discuss the results of a study which investigated students' development of higher-level thinking skills in a computerized learning environment which was designed to facilitate an inquiry-based approach to learning. The study involved an interpretive research approach which was supplemented by the analysis of quantitative data obtained from questionnaires. The original theoretical framework of the study, which was based on the field of inquiry learning, was extended to include constructivist perspectives. Interpretive analyses of data were conducted from personal and social constructivist perspectives, and led to the formulation of four assertions. In particular, the session will focus on the third and fourth assertions which address the social interactions and the influence of teachers' epistemologies on the development of students' higher-level thinking skills. In the class where the teacher implemented a constructivi oriented approach to teaching that emphasized both the personal and social construction of students' knowledge, most students developed higher-level thinking skills. The results of this study suggest that it is not the computer itself which facilitates inquiry learning; the facilitative role of the teacher is essential for students to be able to utilize the computer as a tool of scientific inquiry.

22.02

THE NATURE OF SCIENTIFIC KNOWLEDGE: STUDENT BELIEFS AND THE INFLUENCE OF SCIENCE CURRICULA

Yvonne Meichtry, University of Wisconsin at Stevens Point,
Glenn Markle, University of Cincinnati, and
Jerry Ivins, Northwest School, District, Ohio

The purpose of this study was to measure the growth of middle school student understanding of the amoral, creative, developmental, testable, and unified nature of scientific knowledge over a two-year period. The experimental group, which used a BSCS field test program, and the control group, which used a more traditional science program, were

22.02 MEICHTRY CONTINUED

administered a pretest, posttest, and delayed posttest using the Modified Nature of Scientific knowledge Scale. Analysis of the results showed that student understanding of the nature of scientific knowledge was inadequate throughout the study, that there was no practical difference in student understanding over the two-year period, and that there was no practical difference in the understanding between students in the two groups. Implications are related to the constructivist view of learning and the development and use of curricula to facilitate scientific literacy.

28.02

HISTORY OF THE NATIONAL ASSOCIATION FOR RESEARCH IN SCIENCE TEACHING

Karen S. Murphy, Des Moines Schools, and
Paul Joslin, Drake University

The purpose of this study was to collect and organize historical information about NARST and then to construct a written history of the association. The history began with events preceding NARST's founding in 1928 and continued through many portions of its first 64 years. The three main foci were the membership and the two NARST activities the membership deemed most important -- the annual meetings and the journals, Science Education, (1930-61) and The Journal of Research in Science Teaching, (1963-P). The historical method was employed and sources were evaluated using both external and internal criticism. The search for relevant information included Association publications, particularly its journals, the archives of the Association, card catalogs and resources of relevant libraries, primarily Teachers College, Columbia University, a variety of indexes and abstracts, pertinent books and journal articles and their bibliographic references, personal files of officers and members, archival correspondence, and data summarized from specially designed questionnaires responded to by past officers and board members and other selected individuals.

28.02

AN INTELLECTUAL TRADITION OF SCIENCE AS A WAY OF KNOWING IN SCIENCE EDUCATION: 1900-1950

J. Steve Oliver and B. Kim Nichols, The University of Georgia

This research began as an attempt to document that the stated goals of science education as represented in the research literature have had recurring themes regarding student outcomes throughout the 20th century. An historical examination of the literature demonstrates that the concept of science as a way of knowing has been one of these continuing intellectual threads. Recent discussion is once again bringing this concept to the forefront. And yet, while the goal of science as a way of knowing can be documented as a consistent theme, the literature rarely identifies it as a feature of the practice of science teaching in schools. The apparent disparity between scholarship and practice points toward what Duschl (1990) has referred to as the **two faces of science** as a primary point of contention between the philosophy and application of the school science curriculum. And as a result, there has been a long-term overshadowing of the intellectual thread of science as a way of knowing by the idea of science as what we know.

28.02

RESEARCH TRENDS IN SCIENCE EDUCATION: A CONTENT ANALYSIS OF 1982-1992

Rebecca J. Pollard, Moreen K. Travis, Elizabeth Bryant, and
Patti Nason, Texas A&M University

The present study attempted to determine the diversity of research in science education. Specifically, through content analysis procedures, the Abstracts of Presented Papers of the Annual Meeting for the National Association for Research in Science Teaching (NARST) were used to identify and analyze major trends in science education research with respect to content and changes across years. Results indicated a rich diversity of research interests with particular concentration in the areas of learning and cognition (specifically as they pertained to prior knowledge), science attitudes and science curriculum. Teacher cognitions and professional development emerged as weaker trends across the ten years with more strength in those areas emerging in most recent years.

INTERNATIONAL SESSIONS (ENGLISH)

20.12

CONSTRUCTIVIST RESEARCH ON STUDENT CONCEPTIONS - A GERMAN PERSPECTIVE

Reinders Duit, IPN-Institute for Science Education at the University of Kiel, Germany

The educational system in Germany is somewhat different from other countries. The school system is still predominantly streamed, and teacher preservice education is split into an **academic** phase at tertiary institutions (like universities) and **induction** phase into practice at institutions controlled by the Ministries of Culture in the 16 states of Germany. Where science instruction in school is concerned, there is usually no general science in grades 5 onwards; students study biology, chemistry and physics as separate subjects. Earth science is part of geography. The features of the educational system have significant impact on the structure of science education research in Germany. The paper addresses this issue and also sketches the role of the IPN, the central institute for research and development in science education. Some attention is given to changes in science education research in the states that belonged to the former DDR. A specific focus is the developments and trends in **constructivist** research on students' conceptions in the different branches of science education in Germany in general and in the IPN in particular.

20.12

DEVELOPMENTS AND TRENDS IN RESEARCH IN SCIENCE EDUCATION: A SCANDINAVIAN PERSPECTIVE

Svein Sjoberg, University of Oslo, Norway

The three Scandinavian countries (Sweden, Denmark and Norway) have a large degree of cultural unity, shared social, political and educational traditions, and similar languages. Science education only recently has been established as a research discipline, and efficient networks and personal contacts have enhanced rapid growth and shared theoretical and empirical approaches. There has been an interest in learning theories (first based on Piagetian stages and later on childrens' alternative ideas in various fields of science and in gender

20.12 SJOBERG CONTINUED

perspectives. Science education researchers have played important roles in official national curriculum work in all three countries, and there is a strong move in the direction of **science for all**- and **scientific literacy** in a wide sense. All three countries also cooperate closely on the international scene (e.g., TIMSS).

22.10

LEARNING FROM OTHER COUNTRIES A CLASSROOM'S TEACHERS EXPERIENCES WITH SECONDARY SCIENCE EDUCATION IN THE NETHERLANDS

Katherine Wiseman, Antwerp International Schools, The Netherlands

This is a report of a pilot study which investigated Dutch secondary science schooling. In the Netherlands a student's journey through secondary school is characterized by intentional tracking and final assessment through national examinations. After the **brugklasse** (the first year/s of secondary school) students are grouped according to ability. Academic success resulting in a secondary school diploma is measured by scores on school-exit examinations, for which published syllabi exist. These two factors impact the events and the dynamics within the classroom and the attitudes of students toward their science studies. Using an ethnographic approach, data was collected through interviews of university professors, a cognitive psychologist, teachers, an administrator, and students, and classroom observations in two secondary schools. This presentation will highlight the obstacles encountered and insights gained by a teacher engaged in research in the classroom, hopefully, to stimulate ideas for science education research in the United States.

22.15

INTERNATIONAL CONSORTIUM FOR RESEARCH IN SCIENCE AND MATHEMATICS EDUCATION: A MODEL FOR INTERNATIONAL EDUCATION RESEARCH

Deyanira Barnett, University of Panama,
Donna Berlin, Ohio State University,
Armando Contreras, University of Los Andes, Venezuela,
Pamela Fraser-Abder, New York University,

22.15 BARNETT CONTINUED

Alejandro Gallard, The Florida State University,
Marlene Hamilton, University of West Indies, Jamaica
John Koran, University of Florida, and
Art White, Ohio State University

The goal of the International Consortium for Research in Science and Mathematics Education (ICRSME) is the improvement of educational opportunities for the school populations of the participating countries. ICRSME focuses on programs for collaborative research, curriculum development, instructional improvement, academic exchange, professional development, innovation initiatives, and shared resource opportunities. Each symposium participant discusses current regional research in science and mathematics education and his or her region's collaboration with other members of the Consortium.

INTERNATIONAL SESSIONS (SPANISH)

1.06

LA CLASE DE CIENCIA DESDE UNA PERSPECTIVA SOCIOCULTURAL

Armando Contreras, Universidad de Los Andes, Trujillo, Venezuela.

Este estudio propone una perspectiva interdisciplinaria, basada en constructos provenientes de la psicología social y la antropologia cognitiva, para describir la clase ciencia y las condiciones de aprenzaje de los estudiantes. Basado en métodos etnográficos, el autor describe a través de viñetas interpretativas, como los estudiantes de una zona agrícola-rural de los Andes Venezolanos, son aculturizados de acuerdo a una forma de pensar donde prevalece la memorización de rutinas, algoritmos, fórmulas y leyes; impidiendo de esta forma su acceso a un conocimiento genuino de la concepciones científicas imbuídas en el curriculum escolar. Dicho estudio discute las implicaciones de esta perspectiva y de las descripciones e interpretaciones para la formación del docente, para el proceso cognitivo del estudiante y para la generación de politicas educativas.

1.06

MODELO PARA LA ENSENANZA DEL PENSAMIENTO CRITICO EN LAS DISCIPLINAS

Lydia de Isaacs, Universidad de Panamá, Panamá

Se investigó el efecto de utilizar un modelo educativo para enseñar las destrezas de pensamiento crítico intergradas con el contenido de un curso introdutorio de enfermería. Se empleó un diseño quasiexperimental con un grupo experimental y uno de control. Con un pretest y un posttest para ambos grupos. La variable dependiente fue el pensamiento crítico según los resultados en la Prueba Cornell Nivel Z para Pensamiento Crítico. Los resultados indicaron que el grupo de estudiantes con el cual se usó el modelo educativo obtuvo resultados muy altos y estadísticamente significativos, comparados con el grupo de control.

1.06

PLANO PILOTO PARA EL MEJORAMIENTO DE LA ENSENANZA DE LAS CIENCIAS Y LA MATEMATICA

Rocio Madrigal, Universidad Nacional Autónoma, Costa Rica, y Teresita Peralta, Universidad de Costa Rica

El proyecto está dirigido a 45 docentes de dos escuelas y dos colegios del Area Metropolitana. Es ejecutado por un equipo de 18 coinvestigadores de las dos universidades participantes. Tiene como fin el desarrollo conjunto de metodologías de enseñanza-aprendizaje congruentes con el enfoque constructivista. Se realizan acciones como: a- talleres de desarrollo profesional, que promueven el análisis de su praxis y de artículos científicos u otros que sustenten el marco teórico conceptual, b- reuniones quincenales por especialidad, c- visitas a los centros educativos, d- evaluación formativa mediante técnicas cualitativas, e- evaluación sumativa, inicialmente con pruebas de conocimiento, f- elaboración de crónicas e informes, tanto de los docentes como de los coinvestigadores. Algunos de los logros obtenidos son: cambio de actitud en los docentes, modificaciones curriculares, desarrollo de estrategias metodológicas para la conformación del equipo de coinvestigadores, y para el trabajo con los docentes. Existe financiamiento del CONICIT para suplir necesidades de material didáctico y audiovisual, además de equipo de laboratorio. Se cuenta también con el apoyo del Ministerio de Educación Pública, que reconoce entre otros, un sobresueldo a los docentes.

7.02

SITUACION LECTORA DE LOS EGRESADOS DE PRIMARIA Y SECUNDARIA: ESTUDIO DIAGNOSTICO.

Mercedes Castillo de Arguello, Nery Ruth Castillo, y Esperanza Duarte F. Centro de Educación Pre-Pasarela, Nicaragua

Como docentes observamos que los estudiantes, en su mayoría, presentan dificultades en el dominio de las habilidades lectoras que requiere el proceso de aprendizaje. En nuestro medio existen muy pocos estudios sobre este campo, por lo que partimos del trabajo monográfico **Problemas de lectura en los estudiantes de primaria y secundaria** realizado en 1975. Este estudio-diagnóstico contempló tres fases: 1a) identificación de habilidades lectoras en

7.02 CASTILLO DE ARGUELLO CONTINUED

promovidos de primaria y secundaria 2a) Experimentación de la lectura como método de enseñanza-aprendizaje y 3a) Capacitación a maestros. En la primera, se analizó las habilidades de comprensión, predicción e interpretación y la eficiencia en la lectura silenciosa. La segunda se desarrolló con estudiantes de primer ingreso de la carrera de educación pre-escolar en la asignatura Técnicas de lectura, utilizando como método la lectura, iniciando con un pre-test sobre habilidades lectoras y culminando con un post-test para evaluar la efectividad. La tercera, parte de la necesidad de capacitar al maestro en el dominio de la lectura como proceso y sus implicaciones metodológicas en el proceso enseñanza-aprendizaje para evitar o corregir los problemas de lectura y elevar la situación lectora de los estudiantes.

7.02

MEJORAMIENTO DEL TRABAJO DOCENTE: UN CASO DE ESTUD10.

Lilia Reyes, Universidad Pedagógica Nacional, Santafe de Bogotá, Colombia

En el departamento de Biología de la Universidad Pedagógica Nacional, junto con otros profesores del área de Biología Vegetal iniciamos el esfuerzo de reflexión sobre nuestro trabajo docente y nos aventuramos en el primer semestre de 1992, a aplicar mapas conceptuales con el propósito de implementar en clase la visión constructivista de nuestra enseñanza y del aprendizaje de los estudiantes. El trabajo se realizó en tres etapas : 1.- Aplicación de un pretest para explorar las concepciones acerca de la **Alternancia de Generaciones** en Botánica, especificamente en la Unidad titulada Plantas sin semilla. 2.- Desarrollo de la nueva estrategia metodológica mediante la construcción de mapas conceptuales de complejidad creciente, tanto por los estudiantes como por la profesora, a partir de las concepciones iniciales. 3.- Evaluación de los mapas individuales por contraste y negociación con los mapas de otros estudiantes y de la profesora. En la elaboración de este trabajo se hicieron evidentes tres dificultades principales: A.-La identificación de conceptos básicos. B.-La falta de interrelaciones significativas entre conceptos. C.-El uso de ejemplos significativos. La efectividad de esta metodología se evidenció

7.02 REYES CONTINUED

contrastando los resultados del pretest de este grupo con los resultados del pretest del grupo inmediatamente anterior enseñado por la misma profesora.

7.02

ANALISIS DE LOS RESULTADOS DE LA PRUEBA DE LAWSON EN UNA MUESTRA DE ESTUDIANTES DEL CURSO PROPEDEUTICO DE MEDICINA 1990 — 1991

Matilde de Samudio, y Alvaro Maturell, CIMECNE, Universidad de Panamá

Dentro del marco teórico provisto por la psicología de Jean Piaget, se examinan los esquemas de pensamiento operacional concreto y operacional formal de una muestra de estudiantes que cursan el curso Propedéutico de medicina en la Universidad de Panamá. Se encontró que el 100 por ciento de los estudiantes ha completado la etapa de pensamiento operacional concreto. La prueba señaló que menos de 50 por ciento de los estudiantes utilizan aisladamente los esquemas de razonamiento combinatorio, control de variables, proporcinalidad y correlación probabilística. Sin embargo, menos del 20 por ciento de la muestra de estudiantes posee pensamiento operacional formal. Estos alumnos, con pensamiento operacional formal, aprobaron el curso propedéutico de física con más del 80 por ciento y aprobaron el curso de Física-Matemática I de la Facultad de Medicina.

8.12

PROYECTO 2000+:EDUCACION EN CIENCIA Y TECNOLOGIA PARA TODOS, UN DESAFIO PARA LOS INVESTIGADORES DE AMERICA LATINA?

Rafael Ferreyra, UNESCO, Paris

Este proyecto, iniciado por la UNESCO, es un intento de mobilización mundial de recursos en favor de la educación en ciencia y tecnología para todos. En su etapa actual está coleccionando datos sobre este tema, particularmente sobre la naturaleza, la necesidad, relación con el desarrollo, estrategias educativas escolares, preparación de docentes, evalución y estrategias no formales de la alfabetización en ciencia y

8.12 FERREYRA CONTINUED

tecnología. Un Foro Internacional que se reunirá en Paris en Julio de 1993 definira orientaciones para programas nacionales que se iniciarán inmediatamente. Se espera amplia cooperacion de los Gobiernos, Organismos No Governamentales, entidades de financiamiento, Universidades y grupos privados. Este proyecto que debera desarrollarse durante varios años, promueve la acciones que deben redundar en mejoramiento de la calidad de la vida, preocupación por el desarrollo y el ambiente y un nuevo estílo de cooperación en materia de educación en ciencia y tecnología, con miras al siglo 21. Por ello plantea un fuerte desafío a los investigadores, y los invita a participar en un esfuerzo de educación mutua junto con todas demas personas que cooperarán es esta empresa.

12.12

ORGANIZACION EPISTEMOLOGICA EN LAS DISCIPLINAS: ANALISIS A LAS ASIGNATURAS INGLES Y MATEMATICAS DE LA EDUCACION BASICA VENEZOLANA

Carlos Perez y Ensony Tovar, Universidad de Oriente, Nucleo de Sucre, Venezuela

En estas investigaciones se definieron las categorías agrupadas en matrices para el análisis de las variables estructura, secuencia y coherencia interna epistemológica en los programas de las asignaturas Inglés y Matématicas de la III Etapa de la Educación Basica Venezolana. El procedimiento metodologico usado fue la tecnica de **Análisis de Contenido**. Los resultados de la variable estructura permitieran inferir que existe pertinencia de los componentes epistemológicos de los programas con los modelos teóricas linguísticos y los modelos matemáticos curriculares. No obstante, se determinó una desarticulación intercomponentes que dificulta captar la estructura del conocimiento en ambas asignaturas en cuanto totalidad. La variable secuencia permitio concluir que existen profundas deficiencias en torno a la progresión epistemológica vertical y espiral de los objetivos y contenidos de los programas. Finalmente, la variable coherencia interna, mostró un comportamiento óptimo como resultado del nivel de derivación entre los objetivos y de los isomorfismos en las relaciones epistemológicas objetivos generales-específicos-contenidos.

12.12

CONDICIONES DE INTERACCION A NIVEL DE EDUCACION MEDIA EN DOS CLASES DE BIOLOGIA: CASO CORO-VENEZUELA.

Antonio Concha T., Universidad de Carabobo, Venezuela

La presente investigación tiene como propósito describir las condiciones de interacción que se establecen en la clase de biología a nivel medio. El contexto se circunscribe a dos clases de biología de la región costera en Venezuela. Mediante el uso de métodos etnográficos, se afirma que los aportes significativos de los alumnos a la clase están en estrecha correspondencia con las estrategias de motivación y participación utilizadas por el profesor. Dicho estudio, desde una perspectiva fenomenológica, busca describir los **actores sociales** del proceso; para ello, contempla dos principios claves: a) el comportamiento de una persona es derivado del modo en que éste define su mundo; y, b) el investigador, mediante la descripción, debe aprehender dicho proceso de acción.

21.09

FORMACION DE EDUCADORES PARA LA ENSENANZA DE CIENCIAS EN COSTA RICA

Gilberto Alfaro-Varela, Universidad Nacional, Heredia, Costa Rica.

La preocupación por reestructurar la escuela en Costa Rica esta basada en concepciones de profesionalismo y la necesidad de colaboración entre los educadores. Este es un estudio interpretativo que intenta explora la cultura y los marcos de referencia que se utilizan para explicar el concepto de profesionalismo en los educadores de ciencias y las necesidades de colaboración como son percibidas por los docentes, formadores de docentes, administradores, supervisores, estudiantes en el sistema educativo Costarricense.

22.12

LA INVESTIGACION EN LA UNAN-MANAGUA: DIAGNOSTICO Y PLANIFICACION PARTICIPATIVA

Ottoniel Arguello H., UNAN-Managua, Nicaragua

22.12 ARGUELLO H. CONTINUED

Las universidades dedicadas al enriquecimiento y difusión de la ciencia y la cultura, cumplen este cometido através de la docencia y la investigación. En países con retraso tecnológico, y por el origen de estas en Latinoámerica, la docencia ocupa el papel preponderante, relegando la investigación, careciendo ésta de impacto en el proceso de enseñanza-aprendizaje y en la solución de problemas sociales. La Universidad Nacional Autónoma de Nicaragua de Managua, no cuenta con políticas ni estrategias definidas para la investigación. Bajo la conducción de la Dirección de Investigación, se inició un proceso participativo para la planificación estratégica de ésta. Concretando los problemas que la afectan, estableciendo la relación causa-efecto entre ellos e identificando los principales. Con base en esta información se plantearon los objetivos estratégicos, resultados intermedios a conseguir y las actividades y tareas a realizar. El Consejo Universitario, máxima autoridad, aprobó el plan. La communidad universitaria ha expresado coincidencia con los resultados logrados hasta ahora. Actualmente, el objetivo es continuar con la conducción de este proceso, motivar la ejecución de las acciones requeridas y evaluarlo periódicamente.

22.12

NIVELES DE LENGUAJE Y COMPLEJIDAD COGNOSCITIVA EN LA ENSENANZA APRENDIZAJE DE LA MATEMATICA EN VENEZUELA

José Vívenes, Universidad de Los Andes, Mérida, Venezuela

Se intenta describir la influencia de la subeducación linguística de los educandos de la escuela secundaria en las dificultades para el aprendizaje de conceptos matemáticos y de lógica verbal así como en el bajo nivel de comunicación de los docentes quienes en su enseñanza no advierten la presencia de este factor. Se analizan las relaciones entre metalenguaje, lenguaje matemático y el contenido conceptual vehiculizado, concluyendo en la necesidad de emprender programas de reeducación de la comprensión de la lectura y de adecuación de la enseñanza de la matemática a las dificultades señaladas.

24.12

RELACION ENTRE LA HABILIDAD DE PENSAMIENTO CRITICO Y DE PENSAMIENTO LOGICO DE ESTUDIANTES UNIVERSITARIOS Y SU RENDIMIENTO ACADEMICO

Deyanira Barnett y Lydia G. de Isaacs, Universidad de Panamá, Panamá

Este estudio pretendía determinar el grado de pensamiento crítico y de pensamiento lógico de los estudiantes que ingresan a las carreras de Enfermería y de Biogía en la Universidad de Panamá. También establecer la correlación existente entre el pensamiento crítico y el pensamiento lógico. Ssi mismo, se deseaba determinar la relación entre el pensamiento crítico y el pensamiento lógico con el rendimiento académico al finalizar el primer semestre de estudios académicos. Los resultados indicaron que los estudiantes poseen un grado minimo de pensamiento crítico y sólo un 2.7 por ciento se encontraban en la etapa lógico-formal según Piaget. La correlación entre el pensamiento lógico y el pensamiento crítico no fue sifnificativa. La relación entre el pensamiento lógico y el rendimiento académico fue buena.

24.12

UN DISENO CURRICULAR PARA LA ENSENANZA DE LA BIOLOGIA EN EDUCACION MEDIA (10° y 11°)

Lilian Pino, Carmen de Chacin y Estrella Benaim, CENAMEC, Venezuela.

En la investigación se prueba en el aula un nuevo diseño curricular para la enseñanza de la Biología en la Educación Media, con enfoque sistémico, ambiental, social, aproximación tecnológica y estrategias didácticas centradas en procesos. El diseño responde a las necesidades educativas diagnosticadas. Participan científicos y docentes del Ministerio de Educación, del CENAMEC, Universidades y Centros de Investigación. Se ensayan los programas, los materiales instructivos y equipos y materiales de laboratorio de bajo costo. El programa de Biología contribuye a la cultura científica de los jóvenes con una formación general y flexible en ciencia con la proyección del conocimiento biológico a problemas sociales y las aplicaciones tecnológicas al trabajo y a la producción. Está estructurado en

24.12 PINO CONTINUED

Unidades: Fundamentos de Biología; Biología y Sociedad; Biotecnología y una unidad que las incorpora a todas en la metodología de la Investigación. Actualmente el ensayo atiende a seis mil estudiantes a nivel nacional. Para 1993-94 se generalizarán los nuevos programas.

24.12
REESTRUCTURACION DEL CURRICULO DE BIOLOGO MARINO DE LA UNIVERSIDAD AUTONOMA DE BAJA CALIFORNIA SUR

Ma. C. Gómez del Prado R., D. Siqueiros B. y C. J. Villavicencio G.
Departamento de Biología Marina, UABCS, A.P. I9-B, La Paz, B.C.S. México

Se realizó un diagnóstico del plan de estudios de la Carrera de Biólogo Marino de la UABCS. La metodología incluyó el análisis de las necesidades sociales, práctica profesional y disciplinas. Con base en lo anterior, se propuso la reestructuración del plan de estudios vigente con un mapa curricular nuevo, tomando en consideración: Definicion de la profesión y perfil terminal; determinación de las disciplinas centrales, asignaturas sustantivas, de apoyo biológicas, de apoyo no biológicas, y básicas; así como la actualización de los contenidos mínimos y la seriación; duración de la carrera, considerándose la reducción del número de semestres (de 9 a 8), la reducción de materias obligatorias, la inclusión de materias sustantivas e introductorias y la organización de materias optativas en orientaciones terminales. Con ello, se pretende orientar mejor al estudiante de Biología Marina hacia lo que sería su campo de acción, o para continuar estudios de posgrado.

27.11
USO DEL COMPUTADOR EN LA ENSENANZA DE LA FISICA

Fernando Molina Focazzio,Universidad Javeriana, Colombia,

Se usa el computador como ayuda didáctica en los primeros cursos de las carreras de Ingeníeria, en los tópicos de fluidos, termodinámica, electricidad y magnetismo. El computador es usado por el estudiante para simular procesos y para construir sistemas expertos capaces de resolver problemas. Durante el proceso de construcción se logra una comprensión creciente de los conceptos físicos involucrados. El

27.11 FOCAZZIO CONTINUED

estudiante se apropia del computador, con asesoría del profesor o de otros estudiantes, desarrollando algoritmos en clase o modificando programas ya existentes. El curso de Física se desarrolla simultanea o posterior a un curso sobre un lenguaje computacional, Pascal, en este caso, siendo el estudiante quien diseña sus propios programas, tomando el control desde el principio. En este trabajo se plantean diversas posibilidades de proyectos para sugerirse en las clases regulares y mostrarse ejemplos de los logros obtenidos.

27.11

ESTUDIO DESCRIPTIVO ACERCA DE LA EDAD EN LA QUE LA ADOLESCENTE PANAMENO ACCEDE AL PENSAMIENTO HIPOTETICO-DEDUCTIVO

María Rosa Montanari Departamento de Investigación y Diagnóstico, Ministerio de Educación, República de Panamá.

El problema que genera la presente investigación es el alto índice de deficiencias que se observa en el aprendizaje de asignaturas como Matemática, Física, Química, y Biología en estudiantes del nivel medio del sistema educativo panameño. Se parte del supuesto teórico según el cual esas dificultades se vinculan con la ausencia de estructuras lógico-formales de la inteligencia y la exigencia de su presencia como condición para la construcción de dichos aprendizajes. El problema relacionado con los lineamientos curriculares y las metodologías de facilitación de los aprendizajes utilizados plantea como hipótesis la existencia de una vinculación entre la edad cronológica de los sujetos y la presencia del pensamiento hipotético-deductivo.

27.11

METAFORAS Y DESARROLLO CONCEPTUAL

Nancy Alvarez Perozo, Universidad de Los Andes, Venezuela.

El trabajo trata de una discusión teórica sobre la utilidad del lenguaje coloquial-tradicional, en particular, la metáfora, en la captación del lenguaje científico. Basados en la teoría de estructuración conceptual de G. Lakoff y M. Johnson, se elaboró la red de metáforas que definen un concepto cómun, el concepto **fluído**, que es el modelo o matriz

27.11 PEROZO CONTINUED

metafórica que ayuda a definir y comprender un concepto científico, como es el caso del concepto **calor**. El estudio evolutivo del concepto **calor** desde la perspectiva de la Física sirve como ejemplo para aplicar la matriz surgida, la cual representa un modelo de estructuración de metáforas de complejidad creciente. Se demuestra el funcionamiento de la matriz en la explicación de las diferentes fases conceptuales del concepto **calor**, para poder recomendar la metáfora como una estrategia en la enseñanza de las ciencias.

INVITED SESSIONS

1.03

THE ROLE OF MODELS AND MODELLING IN SCIENCE EDUCATION

John K. Gilbert, University of Reading, U.K

In Science, a model is the outcome of representing a novel object, event, or idea, in terms of a more familiar object, event, or idea. These outcomes are classified as iconic, analogue, mathematical, or theoretical, dependent on the nature of the sources of the model. There are four grounds which justify an overt treatment of models and modelling in science education. These are because: modelling is an important element in scientific methodology; models are one of the main products of science; models are a major learning tool in science education; models are a major teaching tool in science education.

1.09

SIGNING ONTO AND USING THE NARST-L ELECTRONIC MAIL LIST

Joe Peters and Carol Briscoe, The University of West Florida

The need for an electronic communications network for NARST members was confirmed during the 1992 annual meeting. Since that time, NARST-L, a bitnet listserver was established on a trial basis. Difficulties, such as the appropriate use of the reply command and signing off and onto the list, have detracted from its potential usefulness. This session is designed to be an informational presentation and discussion on how to use the list. Topics will include, but are not limited to, general list information, subscribing to the list, sending messages to the list, signing off of the list, finding out who else is on the list, online help, and communications software. A microcomputer will be available to demonstrate topics covered and handouts on NARST-L, bitnet, listserv, and electronic mail will be available.

8.15

SPLITTING VS. COUNTING: NEW APPROACHES TO MULTIPLICATION AND EXPONENTIAL FUNCTIONS

Jere Confrey, Cornell University.

8.15 CONFREY CONTINUED

Multiplication in schools is taught as repeated addition; its introduction is delayed until after a child obtains facility with adding with carrying and subtracting with borrowing. In this presentation I will introduce the **conceptual primitive** labelled **splitting** and discusses how it is related to multiplication division, ratio and similarity. I use this construct to describe a way of building exponential functions by coordinating splitting and counting structures, and offer historical evidence of the importance of establishing multiplicative worlds independently of counting worlds.

8.16

DEVELOPING SELF-ASSESSMENT SKILLS IN GRADE 3 SCIENCE: THE IMPORTANCE OF LONGITUDINAL STUDIES OF LEARNING

Richard Gunstone, Monash University, and
Telsa Rudd, Huntingtower School

This year-long study aimed to develop self-assessment skills in Grade 3 (age 8-9) students, specifically through the use of concept maps, questionnaires and self-assessment graphs. The content focus of these interventions was science and technology. However, as the research was conducted by the usual class teacher, the broad philosophies underlying the interventions were pervasive through this and other curriculum areas. Evidence of increased abilities in self-assessing was found, e.g. commonly considerable increases in number of terms and complexity in the individual student concept maps focussing on **my learning** and self-assessment across the four occasions on which this task was completed. A major focus of the paper is to consider the importance of the length and naturalistic features of the study to the success of the intervention. Links will be made to two previously related studies, one concerned with developing better thinking strategies in Grade 3 and the other concerned with increasing student use of questioning for metacognitive purposes in Grade 11 physics.

8.16

LEARNING TO TEACH SCIENCE: A LONGITUDINAL STUDY OF DEVELOPMENT.

John Loughran, Monash University.

8.16 LOUGHRAN CONTINUED

This study aimed to understand teachers' conceptions of teaching and learning by exploring issues such as how students learn, what comprises a good lesson, the influences on pedagogy and factors which lead to change. Twenty science graduates who completed their pre-service teacher training in 1990 have been interviewed each year since then to discuss these issues and to describe their teaching experiences. As each of the participants has been involved in the study for a number of years, it has been possible to describe and better understand developments in their pedagogy and how these are shaped by their views of student learning.

8.16

RESEARCHING CURRICULUM REFORM: THE PROBLEMS AND POSSIBILITIES OF LONGITUDINAL STUDIES

Jeff Northfield, Monash University.

Post compulsory education has been the focus of reform throughout the world. In Australia curriculum changes have been ambitious as a response to greater retention rates, gender issues and recent research in learning and teaching. In the science areas, changes have been made to curriculum structure, teaching-learning approaches and assessment procedures. To determine the impact of these changes on retention rates, course selection patterns and classroom teaching and learning has required longitudinal studies. Two major longitudinal studies will be described with examples of the more significant findings presented. These studies have allowed for the study of important issues although carrying out these research designs has created some problems and required the development of some interesting responses to these problems.

10.03

EISENHOWER NATIONAL CLEARINGHOUSE FOR MATHEMATICS AND SCIENCE EDUCATION

Michael H. Klapper and Len Simutis, The Ohio State University

10.03 KLAPPER CONTINUED

For effective reform of science and mathematics education in the United States, teachers will need ready access to the best instructional materials and programs. Good mathematics and science curriculum resources are already available, with more under development. But teachers generally do not have the necessary time to search among the many locations in which these materials might be found. The Eisenhower National Clearinghouse for Mathematics and Science, funded recently by the U.S. Department of Education, will provide a central source through which to find needed materials and information. We shall describe our plans for the structure of the Eisenhower Clearinghouse, the tasks it will undertake, and the products it will deliver. We shall consider the possible impact upon the classroom when large amounts of information are easily accessed by students and teachers; for then the teacher need no longer be a primary information source and will be able to assist students in their searches according to their own agendas. Finally, we shall discuss possible research opportunities associated with a functioning Clearinghouse.

21.11

LOOKING AT AN 14 YEAR LONG ENRICHMENT PROGRAM FOR PRIMARILY INNER CITY AFRICAN AMERICAN CHILDREN AGES 8 TO 14

Elizabeth Bernhardt and Erica Brownstein, Ohio State University, Michele McNichols, Bonita Alick, Ruby Thompson, Tanya Mahone, and John Whitmon, Clark Atlanta University

This session is an overview of the collaborative research program that has been instituted between Clark Atlantic University (CAU) (an historically Black and small liberal arts college) and Ohio State University (OSU)/NCSTL. The participants will present preliminary reports on their data gathering activities and explicate their research questions and designs. The session is principally informational in nature; the researchers hope that the audience can offer some of their concerns and insights into the project.

28.04

BEST PRACTICE IN THE PRESERVICE SCIENCE EDUCATION OF ELEMENTARY SCHOOL TEACHERS

Senta Raizen, Mike Padilla, Carl Berger, Sally Crissman,
Susan Loucks-Horsky, Deborah Ball, The National Center for Improving
Science Education, The NETWORK, Inc., Washington, DC

For the past year the National Center for improving Science Education has been engaged in a study of exemplary practice in the science education of prospective elementary school teachers. The primary objective of the study has been to examine instruction in science content and science teaching methods, including clinical experiences, that constitute programs for preparing prospective teachers to teach K-6 science. In this symposium session, members of the project's study panel will discuss the study's purpose, design, process, and results, including a review of data collected from over 100 postsecondary institutions. The presentation will offer a number of criteria that could be used to distinguish exemplary practice. Profiles of innovations that are in place or in the planning stages at teacher education institutions nationwide will bc highlighted. In addition, issues concerning the implementation of effective programs (for example, interfaculty collaborations and institutional policy changes) will be discussed. During the session, there will be ample time for participants to ask questions of the panelists. Supporting materials will be distributed.

LEARNING SCIENCE

1.01
TOWARD A FRAMEWORK FOR UNDERSTANDING STUDENT ATTRITION FROM SCIENCE

Elisabeth Charron, Montana State University

This paper illustrates the application of two complementary conceptual approaches that together can add to our understanding of student attrition from science coursework and career preparation. The first approach is Kelly's (1989) conceptualization of the engagement/disengagement process. The second is Damon and Hart's (1982) model for the development of self-understanding in children and adolescents. This paper uses both conceptual schemes to organize and interpret responses from 28 seventh and eighth grade students who provided autobiographical **science education histories** during interviews. The paper discusses shortcomings of the underspecified frameworks we currently use to explain attrition from science, and proposes that the work of Kelly, Damon and Hart be a starting pint for the development of a more comprehensive framework.

1.01
THE INFLUENCE OF A NONFORMAL EXPERIENTIAL LEARNING STRATEGY ON FIFTH-GRADE STUDENTS ' KNOWLEDGE AND ATTITUDES TOWARD SNAKES

Cynthia S. Ford, Pittsburgh State University, and
Emmett L. Wright, Kansas State University

Nonformal presentations were given to fifth-grade students to elicit change in knowledge and attitudes toward snakes. Constructivist learning techniques and experiential opportunities were used in the presentations with a pretest/posttest/post-posttest design used for evaluation. A profile of prior knowledge on snakes was obtained from interviews. In one half-hour session with fifth-grade students, the presentations influenced scores measuring knowledge gain and attitude change. Student pretest scores were significantly more positive in the posttests for knowledge of and attitudes toward snakes. The positive attitudes did not erode after a month's time. This study showed that if fifth-grade students are given a program developed with specific

1.01 FORD CONTINUED

teaching techniques, they will use their discoveries to reconstruct alternative conceptions and change attitudes toward targeted wildlife species.

1.01

STUDENT EMPOWERMENT AND ATTITUDE TOWARD SCIENCE

Lawrence P. Sildilk, and Michael D. Piburn, Arizona State University

This study was designed to pursue the question of the relationship between student empowerment and attitude toward science in grades 7 and 8. Subjects are 2,159 students taught by 16 teachers in four middle schools. There are strong relationships between perceptions of empowerment and attitude toward science. If students see themselves as having a great deal of control over events in the classroom, they have a much better attitude than if they see the teacher as a controller. Boys feel less empowered than girls, and classes taught by male teachers report themselves to be less in control than those taught by females. Attitudes of students with female teachers are more positive than those taught by males. The well-documented decline in attitude from the first through the eighth grade might be at least in part the result of a shift from student-centered to teacher-centered classroom climate that seems to be part of the structure of elementary schools.

1.02

A PHENOMENOGRAPHIC APPROACH TO CHANGE IN UNDERSTANDING IN SCIENCE MUSEUMS

Robin J. Beiers and Campbell J. McRobbie,
Queensland University of Technology

It is increasingly being recognized that children's science learning occurs from a variety of sources outside the classroom and that these learning sources have the potential to interact with classroom learning. One of the growth areas in the last decade has been the increasing number of interactive science centers. This study employed phenomenography to investigate the learning that occurred as a result

1.02 BEIERS CONTINUED

of grade 7 students visiting an interactive science museum with an extensive display of exhibits relating to the concept sound. Results showed that most students did show some change in their understanding of this concept and that they regularly drew on their experiences from the visit to explain other related phenomena. The study also documents the levels of understanding students used to explain phenomena associated with the concept sound.

1.02

AN EVALUATION OF THREE APPROACHES FOR WIDENING ELEMENTARY CHILDREN'S VIEWS OF SCIENCE AND SCIENTISTS

Tina Jarvis, Leicester University, England

This paper reports on work investigating the effectiveness of three different intervention strategies designed to widen young children's views of science and scientists. The interventions aim to assist all children, particularly girls and those from non-Caucasian cultures, to develop a greater appreciation of the many ways scientists are involved in business and enterprise and to see themselves as potential scientists. The project was developed with groups of children from ages five to eleven in selected Leicestershire schools representing the different cultural and social groups in the area. The three intervention strategies included the use of group tasks, accounts of women and non-Caucasian scientists, and creative writing based on science experiments in the classroom. The effectiveness of the strategies was assessed by comparing children's views before and after intervention using several approaches. Results indicated which strategies are more suitable for older elementary children and at what age intervention is most effective. The data collected have also enabled an analysis to be made of how elementary children's views of science and scientists vary with respect to age and gender.

5.14

STUDENTS' DECLARATIVE AND PROCEDURAL KNOWLEDGE OF HEAT

Richard J. Bryant, Southeast Missouri State University, and
Edmund A. Marek, University of Oklahoma

This study investigated the hypothesis that students' knowledge of theoretical concepts was represented as domain-specific procedural knowledge. The objectives were (1) to analyze students' declarative and procedural knowledge of the theoretical concept **heat** and (2) to examine the relationships among students' knowledge of heat (declarative and procedural), reasoning ability, age, and gender. The subjects were 153 secondary school science students (age 12.5-18.6 years). Several rule models were proposed representing various levels of procedural knowledge of heat related to three paper-and-pencil tasks. When responses predicted by the rule models were compared to student responses, the rule models accounted for the performance of 72.5%, 79.1%, and 86.3% of the students on the three tasks. The rule models followed by students were related to students' reasoning ability but were largely independent of students' written definitions of heat and temperature. The results suggested that students' verbal declarative knowledge of heat was separate from the procedural knowledge which governed students' performance on heat-related tasks.

5.14

WRITING TO LEARN SCIENCE: THE EFFECT OF JOURNAL WRITING ON PHYSICS ACHIEVEMENT

Larry K. Smith, Snow College

Theories of learning indicate that students learn better by processing information in many different ways and by increasing the depth of the processing. According to the advocates of the write to learn across the curriculum movement, students who engage in frequent exploratory writing in the content areas

should learn more about a subject than students who do not. By writing with an exploratory aim about the day's activities, a student in an inquiry based college physical science lab class is faced to rethink the material and express himself about X in a slow, serial fashion. Of the 354 students in 19 sections that

5.14 SMITH CONTINUED

participated in this study, 214 engaged in regular journal writing about the course content while 140 did not. Analysis of covariance was used to account fa differences in grade point average, SAT scores, number of physical science classes previously taken, and time spent on class material. While many of the students felt the daily journal helped them learn, the analyses demonstrated no significant beneficial effect on achievement at the a = 0.05 level.

5.14

IMAGES OF ELECTRICITY: HOW DO PRACTITIONERS MODEL ELECTRIC CURRENT?

Susan M. Stocklmayer, and David F. Treagust, Curtin University of Technology, Perth, Australia

Research findings indicate that students' understanding of electric current in simple circuits is confused by many alternative conceptions. The model of current which is universally accepted is one of moving electrons in a wire responding to a difference in potential across the ends of the wire. Remedial strategies which have been implemented have all sought to clarify this model for students, to enable them to predict circuit behavior and solve circuit problems. It is possible, however, that this is not the most useful model. An historical analysis of textbooks and an examination of expert images have shown that some early researchers held and many experts do hold a field concept rather than a particle one. The paper addresses the relevance of this alternative model for students.

6.03

PREDICTORS OF ACHIEVEMENT OF 7-12 GRADE STUDENTS IN A DISTRICT SCIENCE FAIR COMPETITION

Charlene M. Czerniak, The University of Toledo

This study examined the relationships among confidence in science and mathematics, anxiety on the day of a science fair, parental support, personal and school demographic data and achievement in a science fair

6.03 CZEMIAK CONTINUED

competition. One hundred seventy-five students in grades 7-12 who enrolled in a district science day in Ohio in March 1992 participated in this study. Confidence in science and mathematics and parental support were measured using scales developed by Campbell (1991). Anxiety was measured using the State-Trait Anxiety Indicator (STAI) (Spielberger, 1983). Numerous demographic variables examined parental levels of education, ethnicity, gender, high school GPA, school's course offerings related to research and science fairs, intention to attend college, and motivation to enter the science fair. Achievement in the district science day was identified as the score given by a pair of judges (superior, excellent, good, satisfactory, poor). Discriminant analysis techniques were used to analyze the data.

6.11

SEMNET BIRDS OF A FEATHER

Kathleen. M. Fisher, Center for Research in Mathematics & Science Education, San Diego State University

This research workshop will bring together researchers who use computer-based semantic network strategies for such activities as science education research, conceptual diagnosis, teaching, promotion of personal knowledge construction, curriculum design, instructional and multimedia design, research design and assessment. A wide variety of participants will present concise summaries of their research findings or innovative applications, sharing one or more networks and/or documentation of methods, curriculum materials or papers which could be productively implemented by others in their work, each followed by brief interaction with the audience. The aim will be to create a relaxed and informal atmosphere in which participants and audience feel free to ask questions and clarify their understandings as the topic shifts and flows under the guidance of the sequence of presenters in the agenda.

8.14

A QUALITATIVE EXAMINATION OF SECONDARY SCHOOL STUDENTS' UNDERSTANDING OF THE NATURE OF SCIENCE: A CASE STUDY OF A SUMMER LABORATORY INTERNSHIP

Julia M. McArthur, The University of Iowa

The investigation -- in conjunction with a quantitative study by McComas -- examines the role of a six to eight week university laboratory internship in developing secondary students' views of the nature of science. In keeping with a qualitative research framework, the researcher -- who was one of the program organizers -- acted as a participant observer making field notes to accompany a series of open-ended interviews conducted at the conclusion of the internship experience. Case records were constructed and a method of constant comparison employed in both data collection and analysis. In general, students discussed methodological elements of scientific investigation, the role of the scientist, school science experiences versus real science and the role of intuition and creativity in research.

8.14

THE EFFECTS OF AN INTENSIVE SUMMER LABORATORY INTERNSHIP FOR SECONDARY STUDENTS ON STUDENTS' UNDERSTANDING OF THE NATURE OF SCIENCE.

William F. McComas, The University of Southern California

The study -- in conjunction with a qualitative investigation by McArthur -- examines the role of a six to eight week university laboratory internship in developing the views of secondary students' with respect to the nature of science. Students were assessed using a newly redesigned gender neutral version of the Test of Understanding Science (TOUS) as part of a pretest/posttest research project. The TOUS provides a total score and subscales (understanding about the scientific enterprise, about scientists and about the methods and aims of science). Any significant changes from pretest to posttest with respect to these scores will be examined in light of other variables such as gender, and length and type of laboratory internship. Positive findings provide support for the notion that experiences such as laboratory internships have the potential to provide students an accurate view of the nature of science thus recommending such

8.14 MCCOMAS CONTINUED

experiences as teaching vehicles to acquaint students with aspects of the philosophy of science.

8.17

3RD AND 5TH GRADE STUDENT IDEAS ABOUT MOON PHASES BEFORE AND AFTER AN EARTH POINT OF VIEW ACTIVITY

Gerald Wm. Foster, DePaul University

Seventy-two third and 58 fifth grade students participated in a study to find out what they understand about moon phase formation. Their explanations were collected before experiencing an earth centered point of view activity. Explanations were collected after the activity to determine if their ideas changed as a result of the activity. Pre- and post-explanations were kept separate by grade levels and were grouped according to similarities and differences. The resulting categories represented not only misconceptions, but also different factors in the formation of moon phases. Results indicated that changes occurred in students' ideas, but more so for fifth graders than for third graders. However, regardless of the age group, the results also demonstrated that some children will hold on to original ideas even if reality contradicts them. Thus like many other science concepts, understanding moon phases occurs in stages. Implications of the study can be related to appropriate moon phase activities and teaching methodology.

10.08

AN INVESTIGATION OF STUDENTS' BELIEFS OF THE NATURE OF SCIENCE AND CONTENT KNOWLEDGE RELATED TO A PROJECT-BASED SCIENCE ENVIRONMENT

Barbara Ellies, and Joseph Krajcik, The University of Michigan

The purpose of this study was to investigate how middle school students' beliefs of the nature of science and their content knowledge changed as a teacher attempted to create a project-based science environment. In project-based science, students and teacher become part of a community of learners during an extended investigation of a driving question. This research used qualitative methods to evaluate student learning and change in beliefs of a target group of **average**

10.08 ELLIES CONTINUED

students in an eighth grade classroom. The project implemented by the veteran teacher focused on acid rain. Semi-structured interviews and open-ended questionnaires were used before and after the unit to determine students' ideas of the nature of science and content knowledge relating to acids and bases. In turn, this student data was analyzed in conjunction with the teacher's case report and journal entries. Preliminary findings indicate that the students related positively to the collaborative nature of the project.

12.04

THE EFFECT OF INTERACTIVE, THREE DIMENSIONAL, HIGH SPEED SIMULATIONS ON HIGH SCHOOL SCIENCE STUDENTS' CONCEPTIONS OF THE MOLECULAR NATURE OF WATER

Gita Hakerem, Linda Shore, and Galina Dobrynina, Polymer
Center Education Projects, Boston University

Computer simulations and **hands-on** activities that let high school science students investigate the molecular structure of water are being developed by undergraduate and graduate student programmers at the Boston University Polymer Center. This study employed analysis of videotaped demonstration interviews, preconceptions surveys, and ethnographic field notes to document high school science students preconceptions of the molecular nature of water and to determine what effect computers and **hands-on** instruction has on those conceptions. We uncovered numerous preconceptions concerning microscopic and macroscopic properties of water. We also found that the visual, highly interactive nature of the simulations helped students adopt more accurate conceptions.

12.04

THE ATOM IS NOT A SOLAR SYSTEM-OR AN ELECTRON CLOUD: METAPHORS AS AIDS TO AND INTERFERERS OF ACQUIRING APPROPRIATE SCIENCE METAPHORS

Mark R. Sandomir, Robert J. Stahl and Michael P. Verdi,
Arizona State University, Tempe

12.04 SANDOMIR CONTINUED

Metaphors are often used in science to illustrate theories and concepts with the assumption that they are highly effective linguistic and instructional tools to aid accurate comprehension. A continuing study being conducted in high school chemistry courses is generating data revealing that popular metaphors, e.g., **The atom is a solar system**, interferes with correct comprehension of the Bohr model, and **The atom is an electron cloud** moves students away from major features of the quantum model. An overview of the constructivist perspective of metaphoric thinking along with detailed procedures used to collect data are presented along with findings from over 300 students enrolled in general to advanced placement chemistry courses. These findings warrant a serious reconsideration of the actual instructional value of using popular metaphoric statements to illustrate atomic theories while suggesting new metaphors that are more consistent with more features of these theories than those now used.

13.04

LEARNING SCIENCE IN THE WORKPLACE: ETHNOGRAPHIC ACCOUNTS OF HIGH SCHOOL STUDENTS AS APPRENTICES IN UNIVERSITY RESEARCH LABORATORIES

Robert Bleicher, University of California, Santa Barbara

This study was an ethnography of high school students working as apprentices in university solid state physics labs, as part of a summer science program. It was designed to explore the learning potential for high school students in such an environment. It examined the socio-communicative interactions between scientists and students and how these constrain/support learning. Video-taped key laboratory instructional events and student public presentations of what they were learning in their labs were submitted to an interactional sociolinguistic analysis. Findings focused on important discourse links between presentations and lab activities. Discourse strategies employed in lab instructional events were modeled in presentations, both in content and form. Students selected a subset of topics they felt most confident with from a range of topics covered in lab instruction. Findings suggest models for teaching strategies that could produce higher levels of

13.04 BLEICHER CONTINUED

achievement, more positive attitudes, and greater interest in school science courses. The characterization of students learning in university research labs will hopefully lay a foundation for a match between doing science in such research labs and doing science in school labs.

13.04

SCIENCE FAIRS AND TEACHING ABOUT THE NATURE OF SCIENCE OR **WOULD CHARLES DARWIN HAVE WON A SCIENCE FAIR?**

Catherine L. Cummins, Louisiana State University

Although widespread, science fairs are very poorly researched. Accordingly, this study focuses on the underrepresentation of nonexperimental, biological science fair projects. These nonexperimental projects gathered and analyzed data using descriptive and/or comparative methods. The database is 1106 abstracts from the botany and zoology categories of the International Science and Engineering Fairs (ISEF) from 1983-1992. The departure from equal representation of experimental and nonexperimental projects in both categories is highly statistically significant. The difference in the award success rate for the two groups is not statistically significant. The evaluation process at the international level validates the quality of nonexperimental projects, and selection against nonexperimental projects occurs prior to this level. Research involving evolutionary concepts is virtually lost by emphasizing experimental methods. Many people who consider themselves scientists would find their research does not satisfy the definitions of the ISEF rules. The literature about science fairs communicates that nonexperimental projects are inferior to experimental. One of the most commonly stated goals of science fairs is to give students the opportunity to participate in the process of science. Emphasizing experimental methods at the expense of descriptive and comparative methods does not convey an accurate

15.03

TALKING TOGETHER ABOUT THE MOON FROM KINDERGARTEN THROUGH GRADUATE SCHOOL

Emily van Zee, University of California at Berkeley,
Akiko Kurose, Marietta Iwasyk, and Barbara Schnabel, Seattle School District, Seattle, Washington,
Judy Wild, Sacred Heart School, Bellevue, Washington, and
James Minstrell, Dorothy Simpson, and Virgina Stimpson, Mercer Island School District, Mercer island, Washington

This study is part of an on-going research program to examine classroom conversations in which students are actively engaged in investigations of natural phenomena. The primary objectives of this research include providing a) specific examples of conversations about science for teachers interested in engaging students in instructional dialogues, and b) empirical data upon which to base theoretical progress in understanding the nature of productive classroom dialogues. In this paper, we examine conversations about the same topic, the phases of the moon, with students in a wide variety of educational settings. In addition, we demonstrate ways in which examples from studies in precollege classrooms might be directly incorporated into graduate courses for future teachers.

15.04

CONCEPT CLUSTERING AS A MEANS OF ASSESSING PRECONCEPTIONS, MONITORING CONCEPTUAL CHANGE AND PROMOTING CLASSROOM DISCUSSION

William F. Burke, University of Hawaii at Manoa

Assessing a student's knowledge structure and the conceptual changes that accompany instruction would be a valuable source of feedback for both teacher and learner. Various procedures have been used to assess students' understanding of conceptual relationships (e.g., free sort and word association) and construct external models of learners' cognitive structures (e.g., hierarchical trees and concept maps). This study explored the conceptual changes regarding molecular genetics concepts of nineteen undergraduates enrolled in an introductory biology course at the University of Hawaii at Manoa. It employed a repeated linear listing

15.04 BURKE CONTINUED

of concepts based on their perceived relatedness as the data collection technique in a pretest and posttest. The data were analyzed using multidimensional scaling and the results displayed using a three-dimensional graphics program. Examination of pretest results yielded insights into preconceptions of individual students and the class. Posttest results were informative concerning conceptual changes in individuals and the class and in reflecting organizational attributes of student knowledge that may assist in explaining exam grades. The results could be used as diagnostic tools in student advising, feedback for modifying the presentation of course material and the basis for classroom discussion concerning the organization of course content.

15.04

USING THE CONSTRUCTIVIST FRAMEWORK TO DEVELOP MEANINGFUL SCIENCE LESSONS

Rosalina V. Hairston and Susan A. Weber,
University of Southern Mississippi

Eighteen preservice elementary teachers enrolled in a science methods course participated in this pilot study. The study was conducted in four steps: A. Eliciting children's prior knowledge using structured interview; B Developing teaching plans based on the children's prior knowledge; C.Teaching the lessons, and D. Assessment of the lesson plans and the teaching performance. Prior knowledge and three misconceptions about the earth, the solar system, and space exploration were identified. Lessons developed and taught by preservice teachers were experience-based. inquiry oriented, and used hands-on activities suitable to the motor and cognitive levels of the children. The use of various perceptual modes were effective in changing the misconceptions of children.

15.04

METHODS FOR ANALYZING INTERACTIONS IN COOPERATIVE PROBLEM-SOLVING GROUPS

Mark Hollabaugh, Normandale Community College, and
Patricia Heller, University of Minnesota

15.04 HOLLABAUGH CONTINUED

Students in a University of Minnesota introductory physics course were videotaped while solving physics problems in cooperative groups. The objective of the study was to better understand the types of interactions in a cooperative problem-solving group that produced more effective problem solutions. Sixteen groups comprise this case study. To analyze the interactions between the students in the group, a method was devised that considered not only the types of statements students made, but also the overall manner in which their problem-solving arguments progressed. The basic unit of analysis was the episode. It was found that H is more efficacious to characterize the group by types and completeness of episodes as opposed to the types of statements. Groups with a higher degree of elaboration in their episodes tended to produce better quality physics descriptions in their problem solutions.

15.11

TEACHING AND LEARNING SCIENCE WITH ANALOGIES

Shawn M Glynn, University of Georgia,
Reinders Duit, University of Kiel, Germany,
Rodney B Thiele, Grady Venville, David F Treagust, and Allan Harrison,
Curtin University of Technology, Perth Australia
Zoubeida Dagher, University of Delaware
John Clement, University of Massachusetts.

This symposium provides a critical analysis of the role of analogies in science teaching and learning. Two studies analyze analogies in science textbooks, the first for the purpose of developing a model for teaching and the second for the purpose of comparing analogies used in chemistry and biology. Two further studies examine teachers' explanations using analogies, in one instance to identify the contextual and substantive characteristics of their use and in the second case to evaluate a model for teaching with analogies. The analysis of analogy use in textbooks and teacher explanations suggests that different disciplines of science use analogies in different ways. Contextual influences play an important part in the use of analogies in textbooks and teachers' lessons; consequently, caution must be employed when interpreting research promoting one specific format or explanation of

15.11 GLYNN CONTINUED

analogy use as being most effective. While the findings of the studies are promising, analogical instruction needs further study to determine whether analogies used in textbooks or in teacher presentations can produce understanding described as genuine conceptual change.

19.04

RELATIONSHIPS BETWEEN STUDENTS' MEANINGFUL LEARNING ORIENTATION, LEVEL OF COGNITIVE OPERATION AND THEIR UNDERSTANDING OF GENETICS TOPICS

Ann M. L. Cavallo and Raymond Miller, The University of Oklahoma, and Carl Surber, Norman School District

The purpose of this study was to explore relationships between high school students' (N=130) meaningful learning orientation, prior knowledge, level of cognitive operation and the acquisition of meaningful understanding of genetics and ability to solve genetics problems. Measures of students' meaningful learning orientation (meaningful, rote) (Cavallo, 1991), prior knowledge of meiosis and logical thinking ability (concrete, formal) were obtained. Students were tested before and after laboratory-based genetics instruction using traditional assessments (multiple-choice questions) and open-ended (mental model) assessments (Mosenthal & Kirsch, 1991). The assessment instruments were designed to measure students' interrelated understandings of genetics and their ability to solve and interpret problems using Punnett square diagrams. Correlations and stepwise multiple regression analyses were used to examine relationships between meaningful learning orientation, prior knowledge of meiosis, level of cognitive operation, and students' meaningful understanding and ability to solve genetics problems. The results of this research provide information for educators on students' acquisition of interrelated, meaningful understandings of genetics.

19.04

ADOLESCENTS' UNDERSTANDING OF COMPLEX BIOLOGICAL PHENOMENA IN RELATION TO THEIR COGNITIVE STYLES.

Rodolphe M.J. Toussaint, Université du Québec a Trois-Rivieres

Knowledge in the biological sciences have developed and multiplied mainly because of concepts developed in interconnected sciences. It is no longer possible to consider the unique dimension of structural and descriptive biology while ignoring its functional and evolutionary aspects. Nevertheless, a strong tendency exists to reduce the biological sciences to physical and chemical dogmas and principles, mainly because of the neopositivist field of thought characterized by the Vienna Circle philosophers of the beginning of this century. A new systemic approach is proposed that would take into account the particular characteristics of biological phenomena without recourse to metaphysical nor anthropocentric explanations. Relying on this new paradigm and avoiding all reductionism, we can imagine new pedagogical strategies for the biological sciences. Each biosystem may be studied as an entity, its physico-chemical attributes being studied concomitant to its functional and evolutionary history. In this perspective, we should however ponder the possibility for high school adolescents to apprehend complex biological phenomena, some individuals expressing particular difficulties in dealing with complexity. Results of our study, conducted with high school students indicate the influence of cognitive development and cognitive style on learning of complex biosystems.

20.04

EXPERT-NOVICE DIFFERENCES IN HIERARCHICAL ORGANIZATION OF PHYSICS PROBLEM CATEGORIES

Ronald Keith, Emporia State University, and
Patricia Heller, University of Minnesota

Using a hierarchical problem categorization task, characteristics of knowledge structure were investigated for a group of physics experts and three novice groups. The six physics experts were advanced physics graduate students. Thirty undergraduate students organized in three groups of novices were selected from the enrollment of an

20.04 KEITH CONTINUED

introductory physics course for non-majors. Each participant completed a three-part problem sorting task in order to identify basic, subordinate and superordinate problem categories. The results of the categorization task were analyzed in terms of tree structure and category content. In terms of tree structure, no clear differences between expert and novice groups was found. In terms of category content, differences between expert and novice groups were found at all three levels of categorization. At the basic level, expert categories were based on physics principles, whereas novice categories were organized primarily on the basis of problem surface features. In the formation of subordinate categories, experts focused on procedural distinctions, whereas novices emphasized primarily problem surface features. At the superordinate level, experts had two or three categories representing **conservation principles**, **forces and motion**, and **kinematics**. The novice groups differed significantly at this level. Two groups were like the experts and one was significantly different.

20.04

USING CONCEPT MAPS TO COMPARE EXPERT AND NOVICE UNDERSTANDING OF THE SCIENTIFIC APPLICATIONS OF FRACTAL GEOMETRY.

Linda S. Shore and Gita Hakerem, Polymer Center Education Projects, Boston University, and
Paul Hickman, Belmont High School

Computer simulations and **hands-on** activities are being developed by undergraduate and graduate students at the Boston University Polymer Center. These materials are designed to let high school students actively investigate the applications of fractal geometry in scientific research. This study employed concept mapping to determine what effect interactive computer simulations and **hands-on** activities have on the fractal concepts of high school physics students. We also used concept mapping and a quasi-experimental design to compare the fractal conceptions of three groups: (1) high school physics students using the innovative materials (novices); (2) research scientists and undergraduate and graduate student material developers (experts); and

20.04 SHORE CONTINUED

(3) high school physics students with no formal instruction in fractals (controls). Qualitative methods were also employed in the analyses of the maps.

20.14

SOCIAL CONSTRUCTIVISM: BOTANICAL CLASSIFICATION SCHEMES OF ELEMENTARY SCHOOL CHILDREN

Delena Tull, Biology Dept., University of Central Arkansas,
Conway, Arkansas 72035

That there is a social component to children's construction of knowledge about natural phenomena is supported by an examination of children's classification schemes for plants. An ethnographic study was conducted with nine sixth grade children. Of the nine major plant categories used by the children, the labels for eight would be recognized by adults: plants, tree, bush, flowers, cactus, weeds, grass, vines. Category membership for seven categories, while unacceptable to a botanist, would generally be acceptable to adult laymen. The children differed from each other in the plant specimens selected for each category. When asked to designate the best examples of each category, however, the students selected similar specimens for five categories. For those categories (plants, tree, bush, flowers, grass) the children described and selected a clear prototype (best case example). The prototypes were similar between students although category membership was highly idiosyncratic. The children's classification schemes differed from that of botanists but strongly resembled that of adult laymen, demonstrating a socially constructed system of classification. Reliance on a prototype allows communication to occur between individuals despite idiosyncratic differences in meaning.

21.02

FRESHMAN BIOLOGY MAJORS MISCONCEPTIONS ABOUT DIFFUSION AND OSMOSIS

A. Louis Odom, The University of Missouri-Kansas City, and
Lloyd H. Barrow, The University of Missouri-Columbia

The purpose of the study was to determine if male and female freshman college biology majors differ in their understanding of diffusion and osmosis concepts after adjusting for math placement. The major findings were: (1) There is no significant difference between male and female students' scores on the Diffusion and Osmosis Diagnostic Test. (2) Math placement was a significant covariate when assessing understanding of diffusion and osmosis concepts. (3) Major misconceptions were detected in 3 areas:(a) the particulate and random nature of matter, (b) the process of diffusion, and (c) the process of osmosis.

21.02

THE TIPIOA AS A VIABLE EDUCATIONAL OUTCOMES TAXONOMY FOR SCIENCE EDUCATION: AN ALTERNATIVE TO BLOOM'S TAXONOMY

Robert J. Stahl, Arizona State University, Tempe

The Taxonomy of Information Processing Indicators and Outcome Abilities (TIPIOA) is proposed and described as a viable model of describing outcome abilities that may be targeted or result from science instruction at any level. The Information-Constructivist (IC) perspective and research findings that support the model are presented along with clear descriptions and examples of each level of cognitive outcomes included. This is not a modification of Bloom or Gagne. Practical applications of the TIPIOA are provided to guide science curriculum planners, instructional designers, teachers, and student assessment. The model has been used to plan instructional objectives and test items for science units. This model is a significant break from existing paradigms of cognitive taxonomies and views of cognitive outcomes for use by science educators.

21.04

THE EFFECTS OF COOPERATIVE LEARNING ON DIFFERENT ABILITY-LEVEL STUDENTS' PERCEPTIONS OF THE MIDDLE SCHOOL SCIENCE CLASSROOM ENVIRONMENT

Cynthia H. Geer, University of Cincinnati

To analyze the impact of cooperative learning on different ability-level student perceptions of the middle school science classroom environment, students in no cooperative, average cooperative, and high cooperative learning environments were compared to one another on five measures of perception: Cohesiveness, satisfaction, friction, competitiveness, and difficulty. Quantitative data of pretest-posttest design and qualitative data In the form of teacher questionnaires, classroom observations, and informal teacher Interviews were collected. The results demonstrated the dimensions of cohesiveness and competitiveness were significant for the main effect of cooperative learning type, and the main effect of ability group was significant on the cohesiveness measure. No significant interactions were found between type of cooperative learning environment and ability level. Qualitative data were used to explain the quantitative data.

21.04

ENHANCING SCIENCE LEARNING WITHIN COMMUNITIES OF PRACTICE

George E. Glasson and Rosary V. Lalik, Virginia Polytechnic Institute and State University

In this study, we collaborated with a community of practicing elementary teachers as they explored student-centered science and language instruction. The evolution of the community may be characterized as democratic insofar as participation and activities were invitational and teachers and other participants had a voice in its direction. The teachers judged the combination of their active participation in demonstration lessons with their classroom instruction to be helpful in the development of their pedagogical content knowledge. The support network of the community provided a safety net for teachers as they allowed themselves to be learners of science and science instruction. Within the community, teachers were able to make changes in their school. They affected the way materials were organized and distributed and increased the range of science

21.04 GLASSON CONTINUED

instructional materials available. They initiated efforts to seek support beyond the school building for the work they are doing. The teachers created classroom environments where students were able to voice their understandings and make suggestions for their continued learning. This study is significant because it explores a community of practice that occurs naturally within the educational milieu--the community of teachers, administrators and students within an elementary school building.

21.04

STUDENTS' CODING ORIENTATION AND SCHOOL SOCIALIZING CONTEXT IN THEIR RELATION WITH STUDENTS' SCIENTIFIC ACHIEVEMENT

Ana Morais and Fernanda Fontinhas, University of Lisbon

The study is part of a broader research developed by the Project ESSA - Sociological Studies of the Classroom - and is fundamentally based on Bernstein's theory of pedagogic discourse. An analyses was conducted of the relation between students' coding orientation and their science achievement in school as mediated by family (social class, race, gender) and school (pedagogic practice) factors. Particular attention is given to the influence of differential school socializing contexts in changing students' coding orientation and in narrowing the gap between students with different science achievement particularly in competencies which require a high level of abstraction. The data show that students' coding orientation is in general influenced by social class, race and gender and influences achievement in sciences especially in the competencies which require a high level of abstraction. The analysis also shows the importance of the social context of the school in changing both differential coding orientation and science achievement. The study gives some suggestions about sociological characteristics of pedagogic practices particularly favorable to children who possess a restricted coding orientation.

22.04

THE ROLE OF REPRESENTATION SYSTEMS IN PROBLEM SOLVING IN CHEMISTRY

George M. Bodner and Daniel S. Domin, Purdue University

The results of a series of experiments on problem solving in chemistry will be discussed in terms of their implications for the role that representations and multiple representational systems play in determining the success or failure of students working on such tasks. Particular attention will be paid to the representational systems that students use, the difficulties that arise when inappropriate representational systems are used, differences between the internal representations that students and their instructors build from the same external representations, and the power of multiple representation systems for problem solving.

22.04

CONCEPTUAL FRAMEWORKS AND CHEMISTRY PROBLEM-SOLVING

Eileen Lob Lewis, University of California, Berkeley

Chemistry problem-solving is often difficult because it requires the integration of qualitative concepts and quantitative representations of relationships. This study identifies the conceptual frameworks required for such successful integration. It characterizes the reasoning processes, analyzes metacognitive activities, and examines the conceptual models of **novices** and **experts** engaged in the process of solving a nonstandard chemistry problem. While the given problem requires little specific chemistry knowledge and could be solved by a variety of methods, it did require construction of a conceptual representation that proved difficult for both novices and experts. Analyses were performed on videotapes and written materials produced by six pairs of undergraduate students and four college chemistry professors in the process of solving this nonstandard chemistry problem. All subjects were encouraged to **think aloud** as they engaged in the processes. Verbal and written protocols were used to illuminate the details of the problem-solving process. These included characterization of individual and co-constructed conceptual processes, skill at problem analysis and exploration as well as metacognitive activities. The results of these analyses illustrate when knowledge

22.04 LEWIS CONTINUED

integration processes break down and suggest what is required for successful knowledge integration.

22.04

ARE OUR STUDENTS CONCEPTUAL THINKERS OR ALGORITHMIC PROBLEM SOLVERS? USING PAIRED QUESTIONS TO INVESTIGATE CONCEPTUAL VS. ALGORITHMIC THINKING IN FRESHMAN CHEMISTRY

Mary Nakhleh, Purdue University

At all levels of instruction, chemistry educators ask students to solve problems relating to chemical concepts. If they are successful, the professors and secondary teachers often assume that the students have also mastered the underlying concepts which should be used to solve the problems. The author investigated this same assumption with freshman chemistry students by a simple testing strategy. Three matched pairs of test items were incorporated into the final examinations of the introductory chemistry courses for remedial students, science/engineering majors, chemistry majors, and honors students. Each pair dealt with a specific area of chemistry, such as gas laws or density. One question of each set was phrased as a problem which could be answered using an algorithm. The other question was phrased as a conceptual question which required understanding concepts rather than algorithms. Significant differences in performance between the conceptual and algorithmic questions were found in each course and between courses. Implications for the teaching of chemistry problem solving are discussed.

22.04

THE PROBLEMS WITH PROBLEM SOLVING: BRINGING IT TO THE CLASSROOM

Amy J. Phelps, The University of Louisville

Practical strategies were designed and implemented to improve problem solving in high school chemistry classrooms. Students were allowed to work cooperatively on true problems and the teacher assumed the role of resource or facilitator in the classroom. These strategies were then implemented in other high schools as well as

22.04 PHELPS CONTINUED

college chemistry settings. The research design was qualitative in nature and the cultures of the schools was an important factor. Four assertions were developed from the data. Assertion One: Communication is a key to affective problem solving. Assertion Two: The teacher's problem solving approach effects how he/she approaches problem solving with students. Assertion Three: High levels of frustration and ambiguity are inherent with both teachers and students when you do problem solving in school. Assertion Four: The treatment of time in schools and the need for time to do true problem solving are incompatible. The challenges of doing true problem solving within school culture was examined.

24.04

THE GROWTH OF LOGICAL THINKING OF SECONDARY SCHOOL STUDENTS IN TAIWAN

Bao-tyan Hwang, National Taiwan Normal University

The purpose of this study was to investigate the development of logical thinking abilities of 5,000 Taiwanese students, selected by stratified random method, in grades seven through twelve. In addition, the norms of different school levels were also constructed. Two modified Chinese versions of The Test of Logical Thinking (LTA, Form A and LTB, Form B) were constructed by the author. In this research only the data concerning Form B was analyzed. The LTB measures five reasoning modes which include controlling variables, proportional reasoning, probabilistic reasoning, correlational reasoning, and combinatorial logic. The Cronbach's alpha reliability, the split-half reliability, the Rulon reliability, and the KR-reliability were computed for the administrations of the LTB. For analysis, frequencies, means, percentages, standard deviations, and chi-square were computed on all test items, the five modes of reasoning, and total LTB scores. The main results indicated the following: (a) The majority of the students in this sample are not functioning at the formal operational reasoning level. (b) Logical thinking abilities develop progressively with age between the ages of 12 and 15, and reach equilibrium at age 16 . (c) The data from the five thinking modes shows that boys score significantly higher than girls at each of the age levels tested.

24.04

STUDENTS' COMPETENCE IN FORMULATING ALGEBRAIC EQUATIONS REPRESENTING RELATIONS BETWEEN VARIABLES

Nancy E. Kawahara and Joe Becker, University of Illinois at Chicago

The study examines science-oriented students' difficulties in generating algebraic representations of simple word problems involving ratios. Twenty-two fourth year pharmacy students were asked to think aloud as they worked on formulating an algebraic equation to represent the relation between 2 variables given to them in each of 4 word problems. Analysis of the students' protocols reveals that a large number of responses (57 of 88) initially contained an inappropriate expression. Of these 57 responses, 42 eventually produced the appropriate algebraic equation. These 42 responses fall distinctly into two categories. QA responses (quick to abandon) and SA (slow to abandon) the inappropriate expression. In QA responses, students quickly abandoned the inappropriate expression making no attempt to manipulate it algebraically. In SA responses, students manipulated the inappropriate expression and required a substitution procedure in order to recognize that the derived equation was incorrect. The findings suggest that the difficulties many students have are not located in a deficient understanding of ratios, but rather a lack of understanding of the algebraic use of symbols to denote the unspecified values of variables.

24.04

ON THE RADICAL CONSTRUCTIVIST EPISTEMOLOGY OF HEINZ VON FOERSTER

John R. Staver, Kansas State University

As constructivist epistemology moves from the periphery toward the core of a theoretical base for research and practice in science education, it must survive continuing critical examinations. The author's purpose in this paper is to present a synopsis of certain aspects of Heinz von Foerster's radical constructivist epistemology. Specifically discussed is his position on objectivity as a myth, the uncertainty of sense perception, the undifferentiation of encoding

24.04 STAVER CONTINUED

through the senses, and the correlation of knowledge with reality. Also discussed is von Foerster's resolution of the solipsistic dilemma and the potential choice of constructivism as part of the resolution. Finally, the author responds to recent criticisms of constructivism within the context of von Foerster's epistemology.

24.11

COMMUNICATIVE PROCESSES IN HIGH SCHOOL CHEMISTRY CLASSROOMS

Jazlin V. Ebenezer, The University of Manitoba

This paper explores the factors that affect communicative processes in high school chemistry classrooms and examines the types of communication involved in the construction of chemical knowledge. Ethnographic empirical evidence obtained from three different chemistry classrooms provides insights into how communication may either foster or hinder common knowledge in the classroom. Common knowledge in this study refers to the academic knowledge that becomes established as a part of the student's understanding through discourse. Such discourse becomes the contextual basis for further communication and learning in the discipline. The study reveals the importance of first establishing a common knowledge and understanding between the teacher and students so that meaningful communication and knowledge construction can take place.

27.04

UNDERSTANDING MOTIVATION ACHIEVE IN SCIENCE USING RATIONAL DECISION-MAKING, MOTIVATION, AND CHOICE-FRAMING THEORIES

Nancy J. Allen and Frank E. Crawley, Science Education Center, University of Texas at Austin

The purpose of this study was to determine the extent to which students' science achievement intentions can be explained in terms of motivation, choice-framing, and rational-decision theories. In particular, the study investigated three determinants of intentions, namely attitude toward, social support for, and perceptions of control

27.04 ALLEN CONTINUED

over achievement; two motivational constructs, ability and effort; and two conditions of choice framing, one stressing achievement gains and the other achievement losses. Students participating in this study (N=529) were enrolled in science classes, grades 6-12, of rural and city schools located in the central Texas region. Results of the study indicate that science achievement intentions are predictable from knowledge of students' attitudes, social support, and perceptions of control. Also, students associate personal effort with achieving grades of A in science and personal ability with learning and students who rate their science ability as average and are female tend to be easily influenced by the manner in which physics and chemistry grade distributions are presented. Recommendations are offered science teachers and science education researchers.

27.04

MOTIVATION AND CONCEPTUAL CHANGE IN SCIENCE

Robert Boyle and Shirley Magnusson, University of Michigan

Conceptual change models of learning have, for the most part, not addressed the relationship of motivation to learning. Recent work in social psychology examines the construct of epistemic motivation and people's beliefs towards knowledge and knowledge restructuring. This construct provides a helpful framework in understanding why students tend to hold on to alternative conceptions when faced with contradictory evidence in school tasks, thus interfering with conceptual change. The present study examines an instrument designed to measure the epistemic orientation of elementary students. Reliability and validity of the questionnaire are analyzed, and the stability of the construct in upper elementary school students is also examined. The relationship of epistemic motivation to conceptual change learning is also discussed, and implications for further study are presented.

28.11

A COMPARISON OF MAINE AND OREGON STUDENTS' SCIENCE KNOWLEDGE RELATED TO MARINE SCIENCE AND NATURAL RESOURCES

Michael Brody, Montana State University

This paper compares two studies of fourth, eighth and eleventh grade students' understandings of science and natural resource concepts related to the marine environment. The first study assessed student understanding in relation to the Gulf of Maine and was based on interviews with student in the state of Maine. The second study used the same research techniques and assessed students' understanding of science concepts related to the state of Oregon. The sample of public school students, 159 students in 9 Oregon schools and 187 students in 12 Maine schools, were interviewed on a variety of concept principles considered critical to understanding the marine environment. Concepts relate to geology, physical and chemical characteristics of water and the ocean, marine ecology and ocean resources were included. Results are summarized in generalized concept statements which teachers can expect children to possess as well as those that are likely to be missing. Common misconceptions between the studies are also noted. Differences between Oregon and Maine student understanding are discussed in terms of geographical and cultural differences. The results of this analysis have implications for science teaching about the marine environment and the design of science education curriculum materials related to water and water resources.

POLICY AND REFORM

1.02

EDUCATIONAL PRODUCTIVITY AND SCIENCE EDUCATION WITHIN A DEVELOPING COUNTRY

Bruce G. Waldrip, and Geoffrey G. Giddings, Curtin University of Technology

The study combined qualitative (observation, interview and case study techniques) and quantitative (questionnaire and survey instruments) methods. The study attempted to (a) examine in particular the relationship of current teaching practices to a number of variables that may affect students' learning in their science laboratory classrooms, (b) determine which factors affect academic success in an external science achievement examination, and (c) determine whether an educational productivity model in the science education area was applicable. Analysis of data generated found similar science laboratory learning environments across most high schools with one of the environment scales, Open Endedness, as the least favorable scale. Overall students' attitudes towards science were very favorable with boys having a more favorable attitude than girls. Multi-variant analysis showed that science academic achievement was related to quality and quantity of instruction, science laboratory learning environment scales and gender. As in similar studies in other countries, male students perform significantly better than female students in external science achievement examinations. It was of some significance to find female students achieve significantly higher in a practical science process test. Finally, the study identified some specific aspects of current teaching practices involving science learning environments and students' attitudes towards science, in a developing country context.

1.02

A PROPOSAL TO ESTABLISH AN INSTRUMENT CLEARING HOUSE TO SUPPORT COMPARATIVE RESEARCH IN SCIENCE EDUCATION

Richard L. Williams, University of Victoria, Canada

Comparative studies of achievement are widely quoted and misquoted by both educators and politicians alike. Comparative studies which seek to clarify and enlighten cultural and educational differences, while not

1.02 WILLIAMS CONTINUED

yet generating the same public impact, are increasing and generating useful results for science education. A review of developments in comparative research in science education is coupled with a proposal to establish a clearing house for testing instruments which have been or could be translated into various languages. It is hoped that such a service would provide researchers with access to a variety of instruments in a various languages. Examples of instruments already available are included.

7.01

AN EVALUATION OF THE IMPLEMENTATION OF FLORIDA'S COMPREHENSIVE PLAN TO IMPROVE MATHEMATICS, SCIENCE, AND COMPUTER EDUCATION: A CASE STUDY OF ONE SCHOOL DISTRICT

Kenneth L. Shaw, The Florida State University

In conducting the evaluation of the Comprehensive Plan, the researcher has looked at state, district and school level data. This paper will focus on an in-depth case study of one school district's efforts to implement goals consonant with those found in the Comprehensive Plan. Both quantitative and qualitative research designs were used. Data and analysis from the statewide survey were used to prepare follow-up interviews and observations with the County's administrators and teachers. Based on these data, factors were identified which impacted the vertical and horizontal coordination between the district level administrators, school administrators, and teachers.

8.01

PROBABILISTIC REASONING AND SCIENTIFIC LITERACY: SOME IDEAS FOR SCIENCE EDUCATION

Sharon Derry, University of Wisconsin at Madison

Functional and scientific literacy require ability to understand probabilistic reasoning. It has even been argued that probabilistic reasoning is essential to a fulfilled adult life. Yet research indicates that while scientific conceptions of probability have advanced steadily since the sixteenth century, today's lay and professional

8.01 DERRY CONTINUED

views often resemble scientific dogma of earlier centuries. Vygotsky argued that the public grows into the cultural life of the scientist as advancing sophistication in scientific communities motivates the gradual evolution of the human race as a whole. Within this framework, my talk will focus on the connections among science education, math education, and the development of probabilistic reasoning in adult cultures.

8.01

SCIENCE LITERACY: A WORLDWIDE REVIEW OF IDEAS, SOLUTIONS, AND PROBLEMS

John E. Penick, University of Iowa

In preparation for UNESCO's Project 2000+, science educators in 117 countries were asked to provide information relative to six aspects of scientific literacy: Definitions, the knowledge base, the role of the student and teacher, evaluation, teacher education, and informal approaches. Not unexpectedly, definitions are common and vary widely. Almost everyone points to scientific and technological literacy as critical needs for our populations. But, few write about more than definitions. The desired knowledge base as well as the role of the student are uniformly neglected. Some have attempted to measure levels of science literacy but, since definitions are not consistent, those evaluations are not very useful. This discussion group will meet twice, looking at previous ideas and proposing new ones. Ideas, solutions, and obstacles presented will add to the data base for Project 2000+ and help the NARST Delegates to that conference clarify their own ideas.

8.10

PERCEPTIONS OF THE CONTEMPORARY GOALS OF SCIENCE EDUCATION

Maryellen Duffy, and Dana Zeidler, University of Massachusetts, Lowell

This study was conducted to discern high school science teachers' and science supervisors' perceptions of and commitment to the contemporary goals of science education. A 32 item four choice

8.10 DUFFY CONTINUED

category survey was constructed and tested In a manner to increase the validity and reliability and decrease the residual errors. Multiple sources that contained policies relevant to the field of science education including National Science Teachers Association (NSTA), American Association for the Advancement of Science (AAAS), among others, were utilized In the construction of the goals survey. The population chosen for study were science teachers and supervisors who belong to ASCD and represented a diverse geographic and demographic cross-section. Frequencies, weighted means and discriminant analysis were employed to ascertain the strength of conviction to goals and how other variables (e.g. experience, professional development) may be related to perceptions of goals.

8.10

EXEMPLARY TEACHING PRACTICES AND SCIENCE SUBJECTS CURRICULUM REFORM

W.A.J.M. Kuiper, University of Twente, The Netherlands

From August 1993 basic education will be implemented in lower secondary education (age 12 through 15/16) in The Netherlands. This means a.o. the implementation of a core curriculum of 15 subjects, among which physics/chemistry and biology. The most important aim of basic education is a curriculum reform. As far as physics/chemistry and biology education are concerned a shift in emphasis to context- and activity-based learning is strongly advocated. This paper describes the objectives, design and results of explorative case studies of the teaching practices of 4 exemplary physics and 4 exemplary biology teachers in lower secondary education in The Netherlands. The study of exemplary teaching performances of experts could provide support to the improvement of the science subjects teaching practices in the direction of the curriculum reform in view. An important objective of the study is the formulation of specifications for designing context- and activity-based curriculum-materials for physics/chemistry and biology in basic education. The case studies have been conducted between October 1989 and June 1990. Data have been collected by means of direct observation of lessons, interviews, textbook analysis,

8.10 KUIPER CONTINUED

achievement tests analysis and by administering a student questionnaire.

8.10

THE COLLABORATIVE DECISION MAKING PROCESS IN ACTION: A NATURALISTIC STUDY OF TEACHERS CAUSING CHANGE IN ONE MIDWESTERN MIDDLE SCHOOL

Terry A. Scott, Purdue University

While educators agree that reform efforts must be taken in our nation's public schools, the word **reform** carries a different meaning to each person in the reform movement. How do teachers interpret this need for reform? What decisions do they make which influence curriculum and its implementation? How does collaboration with one another impact these decisions? This naturalistic study of six middle school teachers attempted to answer these questions. These teachers knew changes must occur in their curriculum as it was not meeting the needs of their students. The teachers began the change process using grant funding from a large pharmaceutical corporation. In order to observe their collaborative decision making process, I became a participant observer with these teachers. Using (a) field notes, (b) transcripts of meetings and (c) curricular documents, I generated assertions and tested their validity through triangulation. Implications focus on how we can facilitate the reform process in schools.

12.01

ABILITY GROUPING IN SECONDARY SCIENCE: THE RESEARCH BASE VERSUS POLICY TRENDS

Sharon Lynch, The George Washington University

This paper reviews both current policy trends and research concerning the practice of ability grouping in secondary science education. This paper will: a) Briefly review relevant policy statements of key individuals and institutions in order to provide a sense of the breadth and nature of this issue. b) Review (briefly) the findings on science achievement trends of high ability students in international comparisons. c) Examine the research related to ability grouping in

12.01 LYNCH CONTINUED

science education emphasizing the most "influential" and frequently cited points of view. The paper will not so much advocate a specific position as it will attempt to present the discrepancy between the research base and current policy trends, as well as the philosophical differences between different members of the education community.

12.01

A LATENT VARIABLE PATH ANALYSIS MODEL OF SECONDARY PHYSICS ENROLLMENTS IN NEW YORK STATE

Stanley J. Sobolewski, Indiana University of Pennsylvania

The national Percentage of Enrollment in Physics (PEP) at the secondary level has been approximately 20% for the past few decades. For a more scientifically literate citizenry, as well as specialists, to continue the scientific development, it is desirable that more students elect to enroll in physics. Predictor variables for physics enrollment and physics achievement that have been identified previously include a community's socioeconomic status, the availability of physics at the school the sex of the student, the physics curriculum, as well as teacher and student data. This study isolates and identities predictor variables for the PEP of secondary schools in New York. A linear structural relationship model was developed from the data collected. At least eight latent variables were uncovered, which included enrollment in Regent's level courses, variety of math and science courses offered, number of science rooms per student, teacher characteristics, and the facilities available. The number of science rooms per student and variety of courses seems to have the largest effect on physics enrollment. As part of this study, a model constructed in 1972 was confirmed using data from 1991. No statistically significant difference was found between the 1972 model and the 1991 model of physics enrollment.

12.03

THE REFLECTIVE JOURNAL AS AN AGENT OF INTENTIONAL CHANGE

Melissa A. Warden, Ball State University

The purpose of this study was to examine the effect of reflective journal keeping on the intentions of pre-service elementary science teachers to become involved in a strong activity-oriented school science program. Change scores between pre- and post-test administrations of an instrument designed specifically to measure intention toward the behavior of interest revealed that only subjects in the experimental group (i.e. those who had participated in the reflective exercises) continued to show a strong inclination to performing the behavior. Analysis of individual journal entries provided support for the hypothesis that reflection may serve as the issue-relevant cognitive elaboration necessary for persuasion's central route.

13.01

A STUDY OF THE PATTERNS OF SCIENCE TEACHING IN BRITISH COLUMBIA: A BASIS FOR REFORM

Allan MacKinnon, Marvin Wideen, Barbara Moon, and
Tom O'Shea, Simon Fraser University

Concern about the quality of science teaching and curriculum in our schools comes from reports and publications such as the Science Council of Canada Study of 1984, which examined science teaching in all provinces in Canada, and made recommendations for more and better science teaching in Canadian schools. This symposium uses the results of a large study of science, mathematics, and second language teaching as a platform for discussing critical issues regarding both the direction and the implementation of science curriculum reform in the schools. Specifically, the symposium aims to present the results from a study of science teaching that assessed patterns of teaching in the Province of British Columbia, outline a series of provocative arguments concerning both the direction and character of curriculum reform in science education that grow out of this study, and encourage discussion and debate around these issues and the broader context of curriculum reform in education.

13.08

THE PHYSICAL SCIENCE CURRICULUM IN AUSTRIA IN THE MIDDLE SCHOOL GRADES: A CONTRAST WITH RECENT DEVELOPMENTS IN THE U.S.A.

Hermann Sambs, Bundesgymnasium, Berndorf, Austria

After a political decision to keep two branches of education for ten-to-fourteen year old students in Austria, a new curriculum was developed. Fully implemented since 1989, physics, biology, and chemistry are still taught as separate science courses. The teacher has continued to be the sole authority to responsibly interpret the curriculum when instruction is being planned. The use of projects is encouraged to integrate various topics in a subject and to point out connections across subject boundaries. The topics covered are similar in Austria and the U.S.A. Textbooks guide instruction and oral discourse dominates instruction and assessment.

13.08

SCIENCE CURRICULUM REFORM AND THE CASE OF THE DISAPPEARING AGENTS

John Wallace, and Lesley Parker, Curtin University of Technology

This study reports on an emerging phenomenon in the area of curriculum change: the problem of attracting teachers to participate as curriculum leaders or change agents. The paper reports on an Australian study of a state-wide physics curriculum project utilizing a group of school-based volunteers called **link** teachers. Qualitative techniques were used to explore the motivations of the teachers involved and the conditions required to maintain their commitment. It was found that teachers were more likely to be engaged as curriculum leaders when they were involved in the changes at an early stage, when the changes were connected to their practice and when they had a history of success with similar projects. External rewards appeared to be less important than intrinsic motivations although involvement was sustained when teachers' efforts were recognized. Finally and importantly, the curriculum leaders who were able personalize the

13.08 WALLACE CONTINUED

changes, in terms of their own practice and in terms of the provision of support for their colleagues, were able to maintain a high level of ownership and commitment.

15.01

CASE STUDIES OF CURRICULAR REFORM IN SCIENCE, MATHEMATICS AND THINKING ACROSS DISCIPLINES: A VIEW WITHIN AND ACROSS DISCIPLINES

Ronald D. Anderson, and Mary Ann Varanka-Martin, University of Colorado, Boulder

Case studies of nine successful reform endeavors, three each in science, mathematics and thinking across disciplines, conducted over an academic year, are presented as individual cases as well as across site within each of the disciplines and across all sites. The research focuses on the nature of the reforms; the influences, results and dilemmas of the reform; the perspectives of all the actors in the reform, including students; and the interaction of the reform within the entire system. Case studies take a **slice** of the present to understand the past, the present and the future of destinations of the various people involved. Critical events, defined by the policies and actors at the site or by the research literature or recommendations of professional reform groups, are collected as a foundation for the across site analysis. A series of descriptive **snap-shots** as well as matrices reflective of the research questions, conceptual framework and critical events format are produced for all three levels of analysis.

15.01

ENHANCING RESEARCH AND DEVELOPMENT ACTIVITIES FOR MIDDLE SCHOOL AND SECONDARY SCHOOL STUDENTS THROUGH THE NATIONAL SCIENCE FOUNDATION'S YOUNG SCHOLARS PROGRAM

Julia V. Clark, National Science Foundation

In an effort to stimulate students interest in science disciplines and assist them in making an informed decision about a career in science, the National Science Foundation (NSF) initiated in 1988 the Young

15.01 CLARK CONTINUED

Scholars Program. One of the major goals of the program is to provide high ability and high potential middle school and high school students experiences with the scientific enterprise. Students develop awareness of the work of scientists through activities that broaden their understanding of the subject matter. They get first-hand experience in the research process by working side-by-side with scientists and personally interacting with them. In its first four years of operation, the Young Scholars Program supported more than 272 projects which provided enrichment experiences in science, mathematics, and engineering for more than 17,000 high ability and high potential middle school and secondary school students during the summers of 1988-1991. A report on how these research activities offered intellectually challenging experiences for the students and the implications of these experiences for the encouragement and reinforcement of their interest in science careers are highlighted. Information on how institutions affiliated with the National Association for Research In Science Teaching can become involved in the NSF Young Scholars Program is also discussed.

19.01

A UNIVERSITY AND TEACHER QUALITATIVE APPROACH TO ENHANCE SCIENCE TEACHING AND ASSESS PROJECT 2061 CURRICULUM BLOCKS

Mary Jo McGee Brown, The University of Georgia,
Vicky Brantley, Morrow Middle School, and Jo Ellen Roseman,
American Association for the Advancement of Science

This set of papers describes the development of Project 2061 curriculum blocks, demonstrates a qualitative approach to evaluate and revise blocks, and describes how the collaboration of a university researcher and classroom teacher can provide vital information for improving science curriculum blocks and for improving science teaching. The documentation plan used by Project 2061 was developed by a university researcher and includes strategies of participant observation, conversational interviewing, open-ended questionnaires, field diaries, and observational field notes. Data generated by Project 2061 team members at six sites in the United States using this documentation approach informs decisions about

19.01 BROWN CONTINUED

block development, format and connections. Simultaneously, the process enables teachers to be more astute observers of the educational environment and more attentive to understanding students' understandings of scientific notions of how the world works.

20.01

ACHIEVING REFORM IN SCIENCE AND MATHEMATICS EDUCATION: THE CHALLENGE OF INTEGRATION

Wolff-Michael Roth, Simon Fraser University,
M. Jayne Fleener, The University of Oklahoma,
Susan L. Westbrook, North Carolina State University, and
Sarah B. Berenson, and Laura N. Rogers, Center for Research in Mathematics and Science Education, North Carolina State University

This symposium was developed to generate discussion concerning the integration of science and mathematics curricula. Topics for discussion will include innovative authentic activities for science education, the interdependence of conceptual constructions in science and mathematics education, the use of mathematical tools and technology in the science classroom, the impact of the NCTM Standards on science teaching, and suggestions for research and curriculum implementation.

21.03

THE RELATIONSHIP BETWEEN RESEARCH AND REFORM IN SCIENCE EDUCATION

Arthur L. White, National Center for Science Teaching and Learning-Ohio State University, Eva Baker, The National Center for Research on Evaluation Standards and Student Teaching, Bonnie Brunkhorst, Past President of NSTA, Wendell Mohling, President of the NSTA, Shawnee Mission High School, Audrey Champage, National Research Council, NARST Research Committee, Elizabeth Stage, National Research Council, Kenneth G. Tobin, President-Elect of NARST-Florida State University, Emmett L. Wright, President of NARST, Director of Research Agenda Project, Dona Berlin, Ohio State University, Newark, Michael H. Klapper, Ohio State University

21.03 WHITE CONTINUED

This session addresses the relationship between research in science education and the development of curriculum standards and curriculum reform. The panel provides perspectives from varied professional backgrounds and from current efforts with attention to what has occurred in the past, what efforts are currently in progress, and what is needed for the future. The session serves to update the profession as to the processes and the progress of the task forces for setting curriculum standards for science education; for defining a research agenda for science education; and the shifts in research, evaluation, and assessment models which relate to curriculum reform.

22.01

SUPPORTING SCIENCE CURRICULUM REFORM EFFORTS IN PUBLIC SCHOOLS: SUCCESSES, FAILURES, REWARDS AND DILEMMAS

Marcia K. Fetters, Michigan State University
Walter J. Bisard, Central Michigan University

In an environment where resources are limited but concern about public education is widespread, state legislators are increasingly attempting to mandate improvements in curriculum and teaching practices. These trends have affected Michigan as well as other states. To help school districts comply with these mandates science educators develop teacher support and in-service projects. This study reports the results of a follow-up survey and site visits assessing the impact of a series of workshops focusing on district-level science curriculum reform. The purposes of the study are: a) to assess the effects of the workshop on the beliefs about science curriculum and instruction of members of the leadership team that attended the workshop; b) to assess the impact of the leadership teams on curriculum, policies and practices in their school districts. The information gathered from these districts will be analyzed and compared to other studies of curriculum reform projects. This study will add to this body of literature, plus add to the literature examining the influence and impacts of state mandates on science curriculum and instruction.

22.01

FLORIDA'S EFFORTS TO IMPROVE MATHEMATICS AND SCIENCE EDUCATION: STATE LEVEL PERSPECTIVES

Samuel A. Spiegel, The Florida State University

This was conducted as part of a series of studies that examined Florida's efforts to Improve mathematics and science education through the implementation of Florida's Comprehensive Plan for the Improvement of Mathematics. Science and Computer Education, hereafter called the Comprehensive Plan. This study focused on the state level initiatives which were primarily originated and implemented by the Florida Department of Education. A case study approach was utilized to examine the bureaus responsible for the implementation of the initiatives. Data routinely collected by the state was used to document changes in teaching and learning at the district level. The Issues regarding curricular reform were examined as well as progress toward the goals of the Comprehensive Plan.

24.01

PROFESSIONAL DEVELOPMENT SCHOOLS: FINDING, DEFINING AND CREATING NEW ROLES FOR DOCTORAL STUDENTS

Elaine Oren, Marcia Fetters, and Paul Vellom, Michigan State University

This study consists of a project designed to explore the rewards and dilemmas of university-based science education personnel working in a public school. In particular the study examines the roles of doctoral students teaching and conducting research in the science department of a Professional Development School (PDS). The participants constructed a procedure to collect and compare our experiences as doctoral students working in a PDS. The procedure took the form of a reflective analysis in which we addressed pertinent topics in writing, and then recorded and analyzed structured conversations which used our individual responses as a starting point. The study revealed our concern with defining and fulfilling the roles that doctoral students play in this PDS, and how the expectations and duties of these roles are perceived by the individuals within them as well as by the institutions of the university and the public school. Rewards and dilemmas associated with these roles, such as the participation of university-based personnel in

24.01 OREN CONTINUED

the process of science education reform and the time and loyalty conflicts engendered by such activities are discussed. Implications for the successful implementation of university-generated research knowledge in the high school science classroom, and more generally, the dynamics intrinsic in the evolution of public school and university school of education collaboration are introduced.

24.11

IMPACT OF A UNIVERSITY'S PHYSICS ENTRANCE REQUIREMENT ON SECONDARY SCHOOL SCIENCE

Michael H. McCoy, and Ronald G. Good, Louisiana State University

24.11 MCCOY CONTINUED

The study was conducted in four phases. A. Procurement of data from the state department of education has revealed, (a) the university's academic physics entrance requirement has doubled the number of students enrolled in secondary physics, (b) teachers certified in increased from O in 1984 to 35 in 1989, (c) physics faculty has increased by 20%, and (d) classes of physics taught escalated 42%. B. A census to examine superintendent, principal, and physics teacher attitudes before and after the physics requirement indicates a shift in sentiment favoring the requirement and increases in female and ethnic minority students. C. A study including class observations, teacher and principal interviews, and document analyses is presently under way in public and nonpublic schools to assess impact. D. Triangulation will provide a holistic picture of the impact the university academic physics requirement for all freshmen has had on secondary science in Louisiana.

27.09

FORMATIVE AND SUMMATIVE ASSESSMENT OF A REFORM PROJECT: MODELS OF CHANGE

Linda W. Crow, Baylor College of Medicine
and Ronald J. Bonnstetter, The University of Nebraska

The need for science education reform has been discussed extensively in the literature. However, few educational reform efforts have undertaken the task of documenting the process. The purpose, of this symposium is to promote a discussion of implementation models by examining a current assessment package that includes both formative and summative data for a national reform effort. This open forum will build from the implementation model presented and lay the ground work for a more holistic view of an assessment process that probes the entire school culture including parents, administrators, teachers, and students. Many believe that the science education reform of the 1960s failed due to a flawed implementation process. We must expose the process of reform if we truly expect the final product to be different.

ROLE OF LANGUAGE

28.09

BUILDING CONTEXTS FOR LEARNING AND GENERATING KNOWLEDGE: STUDENTS' USE OF LANGUAGE IN A SMALL GROUP CONCEPT MAPPING ACTIVITY

Carol Briscoe, University of West Florida

This study examines how students use communication during small group interaction to make sense of science concepts and order them hierarchically in a concept map. Theoretical perspectives based on the work of von Glasersfeld and Vygotsky are used in the interpretation of data from tape recordings of students during the activity. Findings suggest that as students use familiar language to communicate with one another during a focusing activity such as concept mapping they are enabled to make sense of science concepts in new ways, organize and generate new connections among the concepts which they were unable to construct on their own. Furthermore the findings demonstrate how interventions by the teacher during group discussion substantially change the nature of the collaborative activity. This study explicates the contrastive nature of interactions possible in classrooms and the untapped power teachers have in fostering group interaction structures which lead to peer teaching-learning. Teachers must become aware of the importance and complexity of talk and its relationship to the construction of conceptual structures and to the development of cognitive skills. Through research activities similar to this study, teachers, as researchers, may learn to enhance development of collaborative learning environments in their own classrooms.

28.09

MIDDLE SCHOOL STUDENTS' METACOGNITIVE AWARENESS OF SCIENCE READING AND SCIENCE TEXT: MODEL VERIFICATION

Larry D. Yore, University of Victoria,
Madge T. Craig, University of North Texas, and
Thomas O. Maquire, University of Alberta

The cognitive sciences have emphasized the need for developing models, generating accurate measures of these models, and deductively verifying the models. Oblique and orthogonal factor

28.09 YORE CONTINUED

analytical techniques that prescribe the number of principal components and theorize the unifying relationships in advance are good, first approximations in verifying simple models. More complex models must be verified using a linear structural modelling technique, such as LISREL-7, that identifies competing relationships and determines their relative strengths. This presentation reports on the verification of a metacognitive awareness of science reading and science text model containing 21 strategic factors, three types of knowledge (declarative, procedural, conditional), three general considerations (reading, text, specific strategies), and five or seven functions (reading, text, motivation, strategy selection, simple strategies, complex strategies, executive control strategies). Data from 532 middle school students (grades 4-8) on a 63-item, multiple-choice instrument with an open response-option designed to assess the model were the factors analyzed. The orthogonal factor analyses indicated that the orthogonal assumption was questionable. The oblique factor analyses produced reasonable fits for the three principal component model involving the general considerations. The LISREL-7 analysis indicated that several of the interpretations of model were competing to various degrees.

SCIENCE TEACHER EDUCATION

1.02

CHEMICAL EQUILIBRIUM: A CASE STUDY OF TEACHING FOR UNDERSTANDING

Arthur N. Geddis, Kamini Jaipal, and Sharon H. Haggerty, University of Western Ontario

This work is part of an ongoing research project documenting the pedagogical content knowledge employed by teachers in transforming subject matter for instruction. The first part of the paper focuses on articulating indicators of students' understandings. The second part is a case study, based on interviews and direct classroom observation, of Mr. Anton's teaching of chemical equilibrium. The study reveals Mr. Anton's skilful use of (a) concrete analogies, (b) practical examples, and (c) a teaching strategy that weaves rather deftly **micro-** and **macro-level** explanatory schemes. Also, it reveals the absence of any direct use of the research literature on students' misconceptions, and little attention to issues of conceptual saliency--why the concept of equilibrium reactions is needed--and curricular saliency--how the topic is related to the rest of the chemistry curriculum.

1.02

CHANGING PERSPECTIVES ON SCIENCE TEACHING

Sharon Haggerty, Art Geddis & Steve Fernandes, University of Western Ontario

Personal Perspectives on Science Teaching is an ongoing research study examining the perspectives of science teachers as they proceed through their post-baccalaureate year of preservice teacher education and their first two years of teaching. This presentation will report on the teachers' perspectives on teaching. Data were collected on four occasions. A questionnaire was administered at the first class meeting of the science methods course. Subsequently, two interviews were conducted during the preservice program, and another at the mid-point of the first teaching year. In summary, findings were that student teachers initially had a very limited understanding of what was involved in teaching, a view that was primarily based on their experiences in university science courses. Interestingly, even when

1.02 HAGGERTY CONTINUED

presented with their original responses, they often failed to recognize that their views had changed. Pointing out the changes initiated a fruitful discussion as they reflected on their learning and teaching experiences.

1.02

CONCEPTUALIZING SCIENCE TEACHER THINKING

Douglas A. Roberts, Audrey M. Chastko, Dougal MacDonald, The University of Calgary; and Peter Chin, University of British Columbia, Canada

This poster session focusses on a project which investigated the way novice and experienced science teachers think about, and rethink, the events of teaching science in secondary schools. Centered around the heuristic device of a teacher's "image of science teaching appropriate for schools" (ISTAS), the research targets events at two periods in a teacher's career: Induction, and a time of substantial curriculum change. The following four papers will be used as focal points for discussion: (l) Broadening the scope of issues deemed important by novice science teachers (Chastko). (2) Detecting how novice science teachers relate their thinking to their practice (MacDonald), (3) Supervising teachers and novices talk about science teaching (Chin), and (4) A significant STS challenge for science teachers: The strangeness of technological and practical reasoning (Roberts).

1.02

RESTRUCTURING THE TEACHER EDUCATION PROGRAM: CONCURRENT AND CONSECUTIVE DEGREES FOR SCIENCE TEACHERS

Karen Sullenger, University of New Brunswick

There Is a general consensus that teachers at all levels need stronger academic backgrounds. The major debate within the Canadian educational community Is whether a Bachelor of Education degree (B.Ed.), which is required of all teachers, should be earned along with or after an academic degree. We are In the final stages of approving a model and establishing appropriate degree programs with other faculties. This proposal focuses on the Bachelors of Science and

1.02 SULLENGER CONTINUED

Education degree programs that members of the committee and the Faculty of Science have proposed. The model is based on two beliefs. One belief is that people who have different interests in science need different programs of study. For example, someone who wants to participate in the conversation of science as a scientist needs a different program of study than someone, like a teacher, who wants to introduce others to the conversation of science. The second belief is that science teachers need to understand the reasoning processes, rules of evidence, conventions, nature, and applications of science as much as they do the models and knowledge of science.

1.02

THE INFLUENCE OF MICROTEACHING ON PRESERVICE TAIWANESE SECONDARY CHEMISTRY TEACHERS' PERCEPTIONS TOWARD TEACHING AS A PROFESSION

Hsiao-lin Tuan, Wu-Hsiung Chiang, and Chen-Kang Lee
National Changhua University of Education, ROC

The purpose of this study was to design a microteaching course that would help preservice chemistry teachers reflect on their teaching practice and view science teaching as a profession. Self-analysis checklists, peer coach, pre- and post- microteaching conferences were implemented to help preservice chemistry teachers reflect on their teaching. A questionnaire designed to evaluate whether preservice secondary chemistry teachers' perceptions changed was also administered before and after a semester of microteaching. Other data sources included transcripts of interviews and lesson plans. The results of the study indicate that although most preservice chemistry teachers held positive views of teaching as a profession, before and after their microteaching experience, these changes were not significant. When they reflected and planned for science teaching, only certain aspects of the teaching event, such as content organization, and expressed behaviors were addressed. Reflections about only ceratin parts of the teaching event might explain why their perceptions about science teaching as a profession changed as they did. Suggestions for future research and for the program are also discussed in the paper

1.04

AN ABSTRACT CONTENT ANALYSIS OF SCIENCE PRACTITIONER JOURNALS FROM 1970 TO 1990

Kimberly S. Roempler and Peter Rillero, The Ohio State University

Journals devoted to classroom science instruction are used by both preservice and inservice teachers. Articles from these journals have been used as references for reports, sources of indepth information, and for the development of lesson plans, units, and curricula. An examination of the content of educational journals can not only uncover important trends in the field of education itself, but unearth areas that receive inadequate coverage. Three NSTA journals were analyzed - Science and Children, The Science Teacher, and The Journal of College Science Teaching. Information about each feature article in the years 1970, 1975, 1980,1985, and 1990 were gathered using the ERIC database. Information taken from each ERIC entry included: main focus (teacher centered, student centered, or neither), science discipline (e.g., physics, chemistry, biology), and other topics such as science activities, demonstrations, lecture method, STS, misconceptions, testing, etc. The analysis revealed that the journals published for teachers of elementary and high school students contain a majority of articles promoting student-centered instruction. Across all levels, biology was the most represented content area. Computer assisted instruction was well represented in all the journals. Other trends and interesting findings are discussed.

1.07

PARTNERSHIPS IN SCIENCE EDUCATION

William S. LaShier and Mike Nelson, University of Kansas

The NSF ShareNet Private-Sector Partnership Project represents a collaborative effort involving education and the private sector and is directed at improving the educational opportunities of students and the professional development of science and mathematics teachers. Membership in the ShareNet partnership presently spans the Greater Kansas City area including both Kansas and Missouri. Fifty-three school districts, the University of Kansas and other area colleges and universities are represented by this partnership. In addition, over 300 business and industry organizations are affiliated through the Silicon

1.07 LASHIER CONTINUED

Prairie Technology Association (SPTA). The goals of this project emphasize the themes of increased relevancy of science instruction for students, heightened problem solving and inquiry skills for students, and accessibility of network technology. Mechanisms to reach these goals include private sector collaboration with educators, training of teachers in various educational technologies, and the development of curriculum and instructional resources. This paper presentation will outline the strategies and outcomes after two years of this project.

1.07

DIALOGICAL INTERACTIONS IN A PROFESSIONAL PRACTICE COMMUNITY: TEACHERS MAKING SENSE OF SCIENCE LEARNING

Sharon E. Nichols, The Florida State University
Betsy Sullivan and Bill Mittman, Sabal Palm Elementary School, Tallahassee, Florida

Over the past two years Florida State University and Sabal Palm Elementary School have developed a Professional Practice Community (PPC). The PPC brings together university educators, prospective and practicing teachers and school administrators to develop partnerships in learning about teaching and learning. Engaging in collegial relationships and collaborative interactions enhances opportunities for participants to critically reflect on their teaching and learning practices, to negotiate strategies to enhance teacher and student learning, and to reconceptualize schools as communities which promote learning as a meaningful life-long endeavor. The means by which participants develop understandings through dialogical interactions within the socio-cultural context of the PPC are critical factors which influence learning in this unique setting. This paper focuses on the dynamics of dialogues within and among PPC participants and implications for improving how public and tertiary institutions interact to enhance teacher and student learning in science education.

1.07

EXAMINING ALTERNATIVE AVENUES FOR IMPROVING I SECONDARY SCIENCE INSTRUCTION BY LINKING PRESERVICE/INSERVICE EDUCATION: THE ISISS PROJECT

Sharon Parsons, Jean Beard, and Dan Walker, San José State **University**

Improving Science Instruction in Secondary Schools (ISISS) is a National Science Foundation (NSF) funded project. The focus of this project is to improve secondary science instruction by working simultaneously with preservice and inservice teachers. A major component of the ISISS project involves providing inservice science education to master teachers who are involved in the field experiences of preservice teachers. The influence of an individual's beliefs on their actions has informed recent research in preservice science education. Some researchers have noted that as with preconceptions of science, preconceptions of teaching and learning that conflict with more pedagogically-appropriate notions may interfere with the student teacher's propensity to personally construct the intended view of teaching, even when that view is the focus of instruction in preservice education. While such studies have focused on identifying the beliefs which preservice teachers bring to secondary science teaching, little attention has been paid to the role of the master teacher in the process. The ISISS Project is a collaborative action research project where we are constructing a model for science teacher enhancement by linking presevice and inservice education.

5.13

THE ROLES OF PARENTS AND TEACHERS IN SCIENCE AND MATH INSTRUCTION: A COMPARISON OF IDEAS OF PARENTS AND TEACHER OF ELEMENTARY STUDENTS INVOLVED WITH A CONSTRUCTIVIST-BASED ELEMENTARY TEACHER PREPARATION PROGRAM

Peggy Daisey and Gail Shroyer, Kansas State University

The paradigm change in elementary science and math instruction from memorizing facts to solving meaningful problems may promote confusion and mistrust between parents and teachers. The purpose of this study is to explore parents' and teachers' perceptions of roles in science and math instruction. Parents (N=94), whose child's teacher

5.13 DAISEY CONTINUED

was involved in a National Science Foundation-sponsored elementary science and math teacher enhancement project, attended one of 21 focus groups or completed a questionnaire (N=157). The 25 K-6 project teachers attended a focus group and completed a questionnaire. Most parents and teachers agreed on reinforcement roles for parents and activity facilitator roles for teachers. However, some parents suggested it was their role to **correct** content and instructional methodology problems in school and a teacher's role was to individualize instruction. Both groups infrequently discussed the role of encouraging girls.

5.13

AN ANALYSIS OF FACTORS THAT SUPPORT PROFESSIONAL DEVELOPMENT SCHOOLS AS SITES FOR A CONSTRUCTIVIST APPROACH TO ELEMENTARY SCIENCE TEACHER PREPARATION

Linda Ramey-Gassert and M. Gail Shroyer, Kansas State University

From a constructivist perspective teacher preparation must be viewed as an extremely complex process involving many interrelated factors. Professional development in teaching must be viewed as a continuum of experiences which mold and shape the ever changing behaviors of the classroom teacher. The Professional Development School (PDS) have come to symbolize a commitment to improving teacher preparation from a complex, holistic perspective while simultaneously improving science instruction in the public schools. These schools facilitate systematic and long-term clinical field experiences for undergraduate preservice students and provide an atmosphere where experienced educators can expand their understanding of effective schooling. The resultant recommendations have been identified from a larger research agenda which focused on change in participants' perceptions, attitudes and beliefs toward mathematics and science, change in science and mathematics instruction in the professional development schools and in university college courses, equity issues in mathematics and science, and an analysis of the process of change within organizations. This paper will present data on the factors which were identified as critical to restructuring elementary science teacher preparation from a constructivist perspective.

5.13

ANALYSIS OF PRE-SERVICE ELEMENTARY TEACHERS' COLLABORATIVE PROBLEM SOLVING IN A CONSTRUCTIVISM- BASED INTERDISCIPLINARY SCIENCE COURSE

Girish Govindarajan and Emmett L. Wright, Kansas State University

The study, part of a National Science Foundation-funded teacher education project, was conducted to address two research questions: 1. In terms of phase levels of deliberation, what is the nature of peer interactions taking place within a group during problem solving cooperative learning science activities spread over a semester's duration in the interdisciplinary course?; and, 2. How have students been affected by the content of the course in terms of their participation in the cooperative learning activities, and their scientific awareness. Data sources included videotaped episodes of peer interactions, students' journal comments, and the administration of a cooperative learning attitudinal survey. The results indicated that group members naturally expressed various non-verbal behaviors - from gestures of support, through display of physical postures characteristic of patient and keen listeners, to non-verbal expressions of frustration as when a group member would experience cognitive and/or socioemotional conflicts during peer deliberations. Also, students' attitude toward working in cooperative learning groups was generally positive and their scientific awareness had been positively enhanced by the use of constructivism-based problem solving hands-on science activities. Overall, they expressed confidence in teaching science, mathematics, and technology concepts and principles using the metric system when they would commence their teaching career.

5.13

RESEARCH RESULTS FROM A CONSTRUCTIVIST LEARNING ENVIRONMENT FOR ELEMENTARY EDUCATION MAJORS: GENERAL BIOLOGY

Lawrence C. Scharmann and Ann Stalheim-Smith, Kansas State University

Students participating in the second semester of an National Science Foundation (NSF)-sponsored science/mathematics enhanced curricular sequence enrolled, as a cohort, in a Teaching Methods for the Biological Sciences course, created to parallel a traditional biology course.

5.13 SCHARMANN CONTINUED

Students experienced a modified version of the traditional course, represented as a week-long Learning Cycle, consisting of an audio-tutorial laboratory (exploration), followed by a recitation section on a subsequent day (concept invention), and finishing with science teaching methods (concept application). Methods class served both to complete each weekly cycle and to model an intact learning cycle as a prototype for organizing and conducting instruction for elementary children. The success of these courses was evident first from an anecdotal perspective; the students were as interactive during the first class session as a traditional section might be only at semester's end. A quantitative data analysis corroborated the anecdotal evidence. The NSF-sponsored section was the best individual recitation section the biology professor had worked with over the past five years. It was also the best among all spring semester sections of the traditional biology course and performed at a statistical level of significance better than the 10 year cumulative grade distribution data for the course.

5.13

KEY ELEMENTS FOR RESTRUCTURING THE ELEMENTARY SCIENCE TEACHER PREPARATION PROGRAM: A CONSTRUCTIVIST PERSPECTIVE

M. Gail Shroyer and Emmett L. Wright, Kansas State University

The paper discusses identified elements that need to be considered in developing and institutionalizing a research-based preservice program to prepare elementary teachers for enhanced science, mathematics, and technology teaching. A program focus is the partnership between the College of Arts and Sciences, the College of Education, and the local public schools. The program includes the development of 32 semester hours of science and mathematics courses specifically designed for preservice elementary teachers, 9 semester hours of instructional methodology integrated and taught in conjunction with the content courses, and 3 years of extensive field experiences in professional development school settings coordinated with the content and methodology courses. A research effort has been established to document and evaluate program effectiveness. Emerging formative findings have identified several critical issues related to successful collaborative efforts for restructuring teacher preparation from a

5.13 SHROYER CONTINUED

constructivist perspective: The establishment of meaningful collaborative goals; the enhancement of ownership and the personal sense of meaning; the establishment of a learning community; the empowerment of teachers and students; the utilization and expansion of the professional knowledge base; and, the accommodation of adult learning styles.

6.01

PROMOTING REFLECTIVE PRACTICE IN SCIENCE TEACHING: A CRITICAL EXAMINATION OF THREE MODELS OF TEACHER DEVELOPMENT

Ann S. Rosebery, Deborah Muscella and Shahaf Gal, TERC, Cambridge, MA.

The goal of this symposium will be to engage presenters and audience in a critical discussion of reflective practice in science teaching as a first step toward defining what we mean by **reflective practice**. The discussion will be based on data from three science education projects which are using distinctly different models of teacher development: A trainer-of-trainers model, a teacher-moderator model using an electronic network, and a research model emphasizing teachers as learners, practitioners and researchers. Each project will present data (e.g., teacher journals, electronic network conference records, videotape) that will serve as the basis for analyzing the commonalities and differences among these models. Presenters and audience will jointly analyze the data to develop a richer understanding of what reflective practice in science teaching is and how it develops.

6.03

EXPLORING LINKAGES BETWEEN ANXIETY, ANGER AND CURIOSITY ABOUT TEACHING SCIENCE AND MATHEMATICS IN PRESERVICE ELEMENTARY TEACHERS

Mary Westerback and Gavrielle Levine, Long Island University

This pilot study examines the relationships among anxiety levels, anger levels, and curiosity levels of pre-service teachers separately and in relation to each other in regard to teaching mathematics and science. Simultaneously, confidence in mathematics, confidence in science,

6.03 WESTERBACK CONTINUED

general confidence and teacher efficacy are also examined. Anxiety, anger and curiosity are measured using the State-Trait Anxiety Inventory, confidence is measured by the SaaS, and Teacher Self-Efficacy is assessed with a scale developed by Czerniak.

6.14

A RESEARCH AGENDA FOR UNIVERSITY-MUSEUM COLLABORATION IN PRESERVICE TEACHER EDUCATION

Marianne Barnes and Lehman Barnes, University of North Florida,
Andrea Anderson, Association of Science and Technology Centers,
Lynne D. Dierking, Smithsonian Institution,
John J. Koran and Mary Lou Koran, University of Florida, and
Roger G. Olstad, University of Washington

This symposium will summarize research on learning in museum and other informal learning settings; present several examples of university/museum collaborations in preservice teacher education; analyze cultural and contextual differences in formal and informal learning settings; examine an interdisciplinary, research-based approach to linking a museum exhibit with teaching materials and strategies; present a developmental model for university/museum collaboration in preservice teacher education; examine portfolio assessment in museums and collaborative programs; and suggest the need for a sustained research agenda which studies teacher preparation in the collaborative contexts of universities and informal learning settings. Presenters have researched learning in informal settings and/or are engaged in university/museum collaborations. Group discussion is encouraged.

7.06

PRESERVICE TEACHERS' ATTITUDES TOWARD USING COMPUTERS AND TOWARD TEACHING

Dorothy L. Gabel and William J. Boone, Indiana University

The Quality University Elementary Science Teaching (QUEST) program at Indiana University for the preparation of prospective elementary teachers has for its goals to strengthen students' conceptual

7.06 GABEL CONTINUED

understanding of science, to deepen their knowledge of the nature of scientific inquiry, and to enhance their ability to use technology in learning and teaching science. This study reports the results of data collection aimed at assessing elementary education majors' views toward computer usage in the classroom and their beliefs about themselves as teachers. The data analysis suggests that overall exposure to computers and attitudes towards computers does not distinguish students who choose a science area of concentration from those who select a different area of concentration. However, students who select the science area of concentration are much more confident with respect to themselves as science teachers.

7.06

EMERGENCE AND INTERACTIONS OF KNOWLEDGE STRUCTURES IN THE PRESERVICE TEACHER

Norman G. Lederman and Mark Latz, Oregon State University

The purpose of this study was to assess the development and changes in preservice science teachers' subject matter and pedagogy knowledge structures as they proceeded in a fifth year teacher preparation program. Twelve preservice science teachers were asked to create representations of their subject matter and pedagogy knowledge structures periodically (five times spanning the entirety of their subject-specific teacher education program) and participate in a videotaped interview concerning the ten representations immediately following the completion of the program. Qualitative analyses of knowledge structure representations and transcribed interviews within and between subjects were performed independently by each of the researchers. Initial knowledge structures were not coherent and typically linear. Although pedagogy structures were highly susceptible to changes as a consequence of the act of teaching, subject matter structures (among these preservice teachers with extensive subject matter backgrounds) were relatively stable. Although there was overlap between the two types of knowledge structures, they were seen to exert separate influences on classroom practice with the pedagogy knowledge structure having primary influence on classroom practice. Implications concerning the

7.06 LEDERMAN CONTINUED

interaction of knowledge structure complexity and translation to classroom practice as well as the current advocacy for increasing subject matter backgrounds or preservice teachers are discussed.

7.06

CONTENT REPRESENTATION: A PART OF THE SCIENCE TEACHING OF PRESERVICE ELEMENTARY TEACHERS?

Mary L. Starr, Joseph S. Krajcik and Phyllis Blumenfeld, The University of Michigan, Ann Arbor

This paper describes the content representations employed by preservice elementary teachers in the first year of preservice teaching in a preparation program emphasizing the teaching of science. Teaching videotapes and audiotaped content interviews and post-teaching sessions were used as data sources. Change in the content representations chosen are also considered. In addition to describing these representations, connections to preservice teachers content knowledge are made in order to inform the science education community about the ways in which content knowledge might alter the representations chosen by preservice teachers. Initial results indicate that initially preservice teacher focus more on the teaching of science process skills. Change in this focus on processes is indicated by the concepts preservice teacher chose to teach in the second semester. In addition, the quality of the few representations that were employed improved. This change was seen most dramatically in those preservice teachers who seemed most comfortable with the content being taught.

7.10

THE CONSTRUCTIVIST TRANSFORMATION OF A PRESERVICE TEACHERS VIEWS ON TEACHING CREATIONISM AND EVOLUTION

William J. Pankratius, University of Nevada, Las Vegas

The general purpose of this study was to explore the consequences of a constructivist approach to an introductory course in teacher education

7.10 PANKRATIUS CONTINUED

and investigate the changes that resulted in preservice teachers attitudes and beliefs about science teaching. Molly, a twenty-eight year old nontraditional student, who wanted to teach English and Biology, had a strong desire to teach creationism in the high school classroom. This study evolved into a case study of the changes revealed in that student's attitude and beliefs towards the teaching of creationism as a result of her personal inquiry. Before Molly started her field investigation she wanted to teach creationism in the biology classroom. As she began her field work, she felt that **the most correct solution is to present both evolution and creationism in the teaching of biology in the public schools**. At the end of her field work, Molly concluded, **By teaching creationism one is opening up a can of worms which may greatly detract from the teaching of science and enter the class into heated religious debate**. Her attitude about teaching creationism changed. She wrote, **A science teacher is only qualified to teach science, not religious beliefs, and I now realize this limitation**.

7.10

LEARNING HOW TO TEACH: A CASE STUDY OF A PROSPECTIVE SECONDARY CHEMISTRY TEACHER'S THINKING AND DECISIONS

Hsiao-lin Tuan, National Changhua University of Education, ROC

The purpose of this study is to describe how a prospective Taiwanese secondary chemistry teacher learns to teach in a one year practicum course. Interpretive research methods were used in this study. Data sources included interview transcripts, classroom observations, and the subject's written documents. Findings of this study show that the prospective teacher holds several beliefs about teaching . These beliefs, and her daily interactions in the classroom, generated several dilemmas for the prospective teacher to solve in her teaching. She solved her dilemmas in the classroom through the use of her previous beliefs and by discussing classroom practices with others. By the end of practicum, the prospective teacher realized her lack of pedagogical content knowledge in teaching. She also gained an awareness of her

7.10 TUAN CONTINUED

students' learning. Suggestions for the science teacher preparation program will be discussed in the paper.

7.11

A NEW VOICE FOR FEMALE ELEMENTARY TEACHERS IN SCIENCE

Sharon Parsons, Catherine DeLauter, and Blanca De La Torre,
San José State University

Whenever the issue of inadequate instruction in science is discussed elementary teachers receive a major portion of the criticism. This has added to elementary teachers viewing themselves as deficient. Since the majority of elementary teachers are females we need to reconsider this issue. An alternate vision would be the viewing of the science education of women as being deficient. Such a position calls for a different approach in teaching females enrolled in preservice elementary science education. One approach is to offer a different view of scientific knowledge which involves preservice teachers in understanding the nature of the construction of scientific knowledge and the envisioning of themselves in such roles as teacher as researcher and teacher as experienced learner. By giving preservice teachers the opportunity to view the construction scientific knowledge differently, it allows an opportunity for a voice. In this case study we will describe the stories of three women(two preservice teachers & a science educator) involved in preservice education who are beginning to construct a new framework for elementary science education.

7.12

PRESERVICE BIOLOGY TEACHERS' CONCEPTIONS OF TEACHING SCIENCE: THE METAMORPHOSIS OF ONE TEACHER'S VIEWS

Perry Allen Cook, University of North Dakota

This is a report on a qualitative, descriptive investigation into conceptions of teaching science held by five preservice biology teachers in a constructivist methods and practicum. The paper focuses on the developments in one teacher's views about teaching science (Gene). The study examined initial and exit conceptions of teaching science, changes in conceptions, and influences on those changes from

7.12 COOK CONTINUED

methods and practicum. Major data sources included: Two sets of Conceptions of Teaching Science interviews concerning beliefs about science, learning, instruction and effective science teaching; two sets of Influence Interviews about significant methods and practicum experiences influencing evolving views; and journals. Gene's initial views about science stressed that science was everything whereas his exit views represented a more conceptual understanding of science. Other developments included a newfound view of the role that probing learners' prior knowledge of content plays in the learning, process and a growing view that a constructivist perspective and conceptual change model offered a useful approach to science teaching. The results suggest important changes did occur in preservice biology teachers' conceptions of teaching science enrolled in a constructivist methods and practicum.

7.12

AN ONTOLOGICAL INVESTIGATION OF AN ENTERING TEACHER

Susan Leopold and Jean Lythcott, Teachers College Columbia University

The study of the education of science teachers is presented as an issue of ontology. Beliefs and conceptions about teaching, learning, learners, science, schooling and assessment co-existing with inner icons, dispositions, values, passions, skills and kinesthetic expression in the lived presentation of a person's way of being as a science teacher require an appeal to ontology. The focus of inquiry in this research program is the process of Becoming, by which is meant the making of oneself as a science teacher. Provided as reading material before the session, the proposal describes the research program: The substrate of knowledge; the questions of inquiry; the people in the study; the methods of inquiry; the nature of the data; and the justification for this research in its preliminary stages. This presentation is the story of a person who became a science teacher, as told in the wide variety of data that were collected. These data are: Oral, written, and visual; produced individually, collaboratively, or in a group process; both formal and informal; and concern the time span from the beginning of the teacher education degree program into the first year of teaching in a New York City public school.

7.12

BECOMING A SCIENCE TEACHER

Jean Lythcott, Teachers College Columbia University

The study of the education of science teachers is presented as an issue of ontology. Beliefs and conceptions about teaching, learning, learners, science, schooling and assessment co-existing with inner icons, dispositions, values, passions, skills and kinesthetic expression in the lived presentation of a person's way of being as a science teacher require an appeal to ontology. The focus of inquiry in this research program is the process of Becoming, by which is meant the making of oneself as a science teacher. Provided as reading material before the session, the proposal describes the research program: the substrate of knowledge; the questions of inquiry; the people in the study; the methods of inquiry; the nature of the data; and the justification for this research in its preliminary stages. The questions illustrate the difference between approaching the problem as one of ontology versus one of cognition. Two presentations from this research program introduce the program itself for discussion. This presentation concerns data that are drawings, made in seminar, of one's Quintessential Teacher, the reflective comments about the drawings and their interpretation made by the artists who are the entering teachers. The methodological context in which the data were generated will also be described.

7.12

CONCEPTIONS OF BIOLOGY BROUGHT TO TEACHER EDUCATION BY PROSPECTIVE SECONDARY TEACHERS

Regina E. Toolin, John Lemberger, and Peter W. Hewson, University of Wisconsin-Madison

An interview to probe for conceptual understanding of selected biological principles in genetics, physiology, and ecology, at a cellular, organismal, and community level was developed and used to interview 10 pre-service biology teachers at the start of their methods course. Analysis showed a great deal of variability with regard to understanding of key concepts in biology. A major in biology seems to be no guarantee that prospective teachers understand important

7.12 TOOLIN CONTINUED

biological concepts in the school curriculum. Many students had difficulty in articulating their views about the nature of science.

7.13

REFLECTIVE PRACTICUMS AND SCIENCE TEACHER EDUCATION

Carole Mitchener, DePaul University

For the past year, I have had the wonderful opportunity of teaching three separate teacher education courses which all contain a reflective practicum as part of the course requirements. Reflective practicums include field experiences that prospective teachers have in elementary and secondary schools as a part of their teacher education, and the reflection on practice (Schon, 1983) that accompanies those experiences. Although these three courses share a commitment to the process of reflective practicums, they varied dramatically in the levels of student involvement in schools. These differences in involvement produced differences in teaching and learning that occurred in each course. The variations in the practicums and the differing impact on the nature of teaching and learning interactions in each of my three education classes serve as the focus of this inquiry. More specifically, this paper will address the following: l) the role of the reflective practicum in educating science teachers; 2) the differing levels of practicum involvement in each of the three courses; 3) the impact each situation had on the course content, the prospective teachers, and the class interactions; and 4) the learnings I had about what it means to teach through student experience.

7.13

THE REVOLUTION OF ENLIGHTENMENT: A HISTORICAL CASE STUDY OF SIGNIFICANT EDUCATIONAL CHANGE THROUGH TEACHER EDUCATION.

Peter Rillero, The Ohio State University

Pestalozzi's object teaching method, derived from Enlightenment thinking, transformed American education in the late 1800s. Examination of object teaching is important because: it was a forerunner of elementary school science, its evolutionary roots underlie modern educational practice, and it provided an impetus to

7.13 RILLERO CONTINUED

the nascent normal school movement. The object teaching revolution is also an important case study of an educational reform that floundered until it utilized teacher education. Early attempts to bring object teaching to America neglected the importance of preparing teachers to enact the changes. Sheldon brought object teaching to Oswego and, as the pioneer in inservice education, held classes to help teachers stress the power of observation instead of the acquisition of knowledge. Soon after, Sheldon started the teacher training school which became known as the **Mother of Normal Schools**. This school combined preservice teacher education with experiences in a practice school and a model school. Sheldon also sought to educate teacher educators,which helped bring about the object teaching revolution. Oswego graduates found employment in normal schools and spread the method. The impact of this revolution on education and its implications as a case study in significant educational change will be discussed.

8.13

APPROACHES TO PERSONAL EMPOWERMENT OF PRESERVICE SCIENCE TEACHERS: ACTION RESEARCH AND ITS CONSEQUENCES

David F. Jackson, Lee Meadows, Thomas R. Koballa, Dee French, Michael J. Padilla, J. Randy McGinnis, Elizabeth Adams, Marsha Carlan, Amber Griffin, John Hall, Sondra P. Hernandez, Jennifer Hughes, Gena Rigdon, Gigi Yoho, Rachel Yuratich, University of Georgia

Teachers' beliefs about teaching and learning are not always congruent with their classroom practices. Ironically, this seems to be particularly true among science teacher educators. Two of the three papers in this set describe, largely in the words of our students, our attempts to operationalize our beliefs about student empowerment and project-centered learning in two preservice pedagogy courses addressing elementary and middle school science teaching. The last paper describes our experiences during the following year, when we participated at both the institutional and statewide level in a major re-examination of both the detailed conduct and the most basic

8.13 JACKSON CONTINUED

principles of science teacher education. Questions raised and insights provided by our students during these preservice courses have frequently emerged as fruitful referents in our deliberations on possible directions for both piecemeal and systemic reform efforts.

10.08

CASE STUDIES OF PROJECT-BASED SCIENCE INSTRUCTION: CHALLENGES OF IMPLEMENTATION

Joseph S. Krajcik, Phyllis Blumenfeld, Ron Marx, Elliot Soloway,
Merri Blunk, Barb Ellies, Bev Kelly, Barb Ladewski, and Karen Mills,
The University of Michigan

The purpose of this symposium is to enhance our understanding of what project-based science instruction is and the challenges teachers face in implementing project-based science. Project-based instruction melds ideas about constructivism and teaching for meaningful understanding into a coherent framework by focusing instruction on a driving question around which central concepts within the curriculum can be integrated. The symposium will have three sections. The first section sets the context for the case studies. We describe: I) the features of project-based science, 2) the projects implemented by the teachers and the support they received, and 3) the procedures used to create the case studies, using an interactive computer-based video analysis tool. In Section II, we present parts of five case studies that illustrates features of project-based science and the challenges teachers faced in implementation. The features of project-based science and the insights emerging from the case studies are illustrated through video. In Section III, we synthesize what we learned from the case studies by describing a) what challenges teachers faced and how teachers met the challenges of project-based instruction, b) how their practices changed, and c) what influenced their changes.

12.03

ELEMENTARY TEACHERS' PERCEPTIONS OF CONCEPTUAL CHANGE SCIENCE TEACHING

Sandra K. Abell and Daniel P. Shepardson, Purdue University

The purpose of this study was to examine elementary teachers' perceptions of conceptual change science teaching during their involvement in a year and a half teacher enhancement project. Through a series of four interviews, we found that participating teachers viewed student involvement as the key element in successful science teaching, adopted a discovery orientation to understanding successful science teaching, and saw conceptual change teaching primarily as a tool for organizing and sequencing instruction. We were ineffective in facilitating a more thorough and accurate understanding of conceptual change science teaching. This study has implications for future teacher enhancement projects that focus on conceptual change teaching in elementary science.

12.03

SCIENCE AT CRANBROOK: AN EVALUATION OF THE IMPACT OF STUDENT TEACHING EXPERIENCES IN A MUSEUM SETTING ON CLASSROOM SCIENCE TEACHING PRACTICES

Dawn Pickard, Oakland University
Rene Givens and Janet Johnson, Cranbrook Institute of Science

For approximately 10 years, Cranbrook Institute of Science and Oakland University have provided Junior and Senior elementary education students with the opportunity to teach science to upper elementary children. During fourteen weeks of a university term, students are asked to teach one or more science lessons approximately three times during the course of a half-day a week experience. Over the years, the program has evolved into a teaching laboratory where students are given several potential lesson plans which they may choose to use or not use. They are overly encouraged to build a conceptual understanding of the topic they are to teach and develop a lesson plan of their own 10 implement in the safety of the museum environment. This study documents a 10-year evaluation of the worth of the program, and its impact on the teaching of science in Michigan elementary schools.

12.09

PRESERVICE ELEMENTARY TEACHERS' DEVELOPMENTAL UNDERSTANDING OF ELEMENTARY SCIENCE CONCEPTS VIA A CONCEPTUAL CHANGE MODEL

Lois M. Campbell, The Pennsylvania State University

The purpose of this study was to observe and document the thoughts and beliefs concerning elementary science concepts (from the content areas of earth, life and physical science) held by preservice elementary education students enrolled in an elementary science methods course. Of special interest in this study was the use of the conceptual change model in the methods course and during a practicum within the methods course. Further, the researcher addressed the preservice teachers' abilities to transform elementary science content knowledge into classroom practice. Through a qualitative study which utilized ethnographic methods (field notes, audio taping, video taping, and artifact analysis) the researcher attempted to develop an understanding via a phenomenological and constructivist base - of how preservice teachers as learners construct an understanding of elementary science concepts through a conceptual change model. In addition, the researcher focused on the use of inquiry and reflection as methods for elementary classroom instruction and how these methods affected the conceptual understandings of preservice elementary teachers.

12.09

PRESERVICE TEACHERS' REPRESENTATIONS OF THE CONCEPTUAL CHANGE MODEL

N. Richard Thorley, University of Rochester, and
René T. Stofflett, Northern Illinois University

One fundamental principle of the Conceptual Change Model (CCM) is that learners must find a conception intelligible before they can accommodate it. Taking the CCM itself to be a focal conception for future conceptual change teachers, this paper describes the manner in which pre-service elementary teachers represented the conditions for, and the process of, conceptual change. The teachers' methods course

12.09 THORLEY CONTINUED

had itself been structured around the CCM. Using a framework for analyzing classroom science discourse developed by the first author, this research involved the analysis of essays in which the teachers had evaluated the extent to which their lesson plans and teaching conformed to the CCM. In describing how scientific conceptions were intelligible, plausible or fruitful to their students, many of the teachers' representations were confined to verbal restatements of the original readings. However, many drew spontaneously on other modes of representation, especially exemplars and metaphors, in representing the conditions of conceptual change. It is concluded that in fostering conceptual change teaching among preservice teachers, there should be a strong emphasis on the reflexive application of the CCM to their own conceptions of teaching and learning, for which the dimensions of the conceptual ecology would provide a valuable framework.

12.11

DEVELOPMENT AND EVALUATION OF AN INTEGRATED SCIENCE/MATHEMATICS ELEMENTARY PRESERVICE METHODS COURSE

Robert A. Lonning and Thomas DeFranco, The University of Connecticut

The course was developed to address impediments to improvement of elementary science education and to conform to a Holmes Group-based teacher preparation program, e.g., previous science experiences have led to an aversion for science, lack of time in an over crowded curriculum for science, lack of training in selection and use of appropriate science materials. Course goals to address these problems included: a) Encouraging students to examine their personal feelings about science and science instruction and understand how these feelings can influence how they teach science. b) Developing an understanding of what science is and that science can be personally meaningful to them and their students. c) Providing students with a small array of quality science activities and the ability and confidence to locate, modify and develop their own science materials. d) Demonstrating to students how science can be incorporated into the elementary curriculum by integrating science with mathematics and other content areas. Qualitative data regarding students' attitudes and self-efficacy towards science and science instruction were collected pre and post. It is

12.11 LONNING CONTINUED

intended that the course model and findings will provide a basis for establishing a shared research agenda at the annual meeting.

12.13

THE ROLE OF MENTORS IN THE INDUCTION OF NEW SCIENCE TEACHERS

Renna B. Calvert, John Wiggins, B. Kim Nichols, and Dee French, The University of Georgia

Induction is that crucial time when students suddenly find themselves as teachers. This study field tested a model which would alleviate some of the most intimidating problems faced by new science teachers. New teachers were assigned two mentors with recent science teaching experience, one from their school and one from the university. The original project involved only an external mentor working with a beginning teacher. The significance of this model is that a third component, an internal mentor, has been added to the support team. Qualitative methods including interviews, participant observation, journals, and document analysis were used to assess beginning teacher needs and the types of support being provided. External mentors from the University proved to be of significant help to the first year teacher. The effectiveness of the external mentor centered around resources provided, flexible scheduling, and serving as a sounding board. Support from both internal and external mentors enabled the first year teachers to function much more confidently and successfully. These teachers need to define, develop, and understand their emotional needs, professional skills, and sense of belonging. External and internal mentors provided the necessary support for the beginning teachers to attain their needs.

12.13

THE MENTORING ROLE IN A SCIENCE INDUCTION MODEL

Dee French, B. Kim Nichols, John R. Wiggins and Renna Calvert, The University of Georgia

Induction research for beginning science teachers is an area of limited research in present literature. The purpose of this qualitative study was to investigate the Impact of a unique science induction model (TST

12.13 FRENCH CONTINUED

- Teacher Support Team). The participating 7 teams were each comprised of an experienced internal mentor paired with a beginning science teacher from within the same school and an external mentor from an area university. Analysis of team interactions, relationships, needs and concerns were conducted through journals, formal interviews, documents, and on-site interviews. Results indicated that in this unique science induction model the internal mentor filled an important role in the triad network by providing additional support particularly In the area of school orientation, socialization, and assistance with dally concerns or questions. Thus, the internal mentor filled an important niche in the model.

12.13

THE TEACHER SUPPORT TEAM APPROACH TO INDUCTION

B. Kim Nichols, Dee French, John Wiggins, and Renna Calvert, The University of Georgia

The purpose of this study was to develop a model program to reduce the difficulties experienced by first year science teachers. Our model involves a team approach to teacher induction; the triad includes the beginning teacher, an internal mentor, and an external mentor. The external mentor was a university science educator who also served as researcher. The internal mentor was an experienced science teacher from the beginning teacher's school. Seven first- year teachers and seven internal mentors were involved in the study. Each triad worked to identify the needs of the beginning teacher; the team then developed strategies to best meet those needs. A qualitative approach was used for data collection. Data included: formal interviews, informal interviews and conversations, fieldnotes from classroom observations, and analysis of documents such as Journals kept by team members. Many of the needs identified are shared by beginning teachers in any field; some, such as laboratory concerns, were specific to science teachers, however. There were three components that made this approach particularly successful in addressing the needs of the first-year teachers: (1) two mentors were assigned to each beginning teacher--an internal and external mentor; (2) both mentors were

12.13 NICHOLS CONTINUED

experienced science educators; and, (3) the needs were determined on an individual basis.

15.09

MATHEMATICS AND SCIENCE PREPARATION OF ELEMENTARY TEACHERS: IMPLICATIONS FOR FACULTY DEVELOPMENT

Craig A. Berg, Donald Neuman, DeAnn Huinker, The University of Wisconsin-Milwaukee.

The goals of the research being described in this proposal were the enhancement of faculty professional development and the improvement of the quality of mathematics and science preparation of elementary teachers. The objectives of this research were to observe and analyze the specific teaching behaviors and strategies of the instructors of mathematics and science courses; to compare their beliefs and rationales to their actions; to create a profile of specific courses and instructors; to compile a profile of specific courses and instructors; and to compare these findings with the desired state of exemplary science and mathematics instruction.

15.09

AN INQUIRY INTO PRESERVICE MIDDLE LEVEL SCIENCE TEACHERS' THINKING ABOUT SCIENCE TEACHING

Rebecca S. Bowers, Old Dominion University

This study, in progress, is being conducted in three parts: A. examining ways middle level preservice science teachers think about science teaching; B. identifying any changes in preservice science teachers' thinking about science teaching during their science content and methods courses; and C. determining how preservice science teachers translate their conceptual schema about science teaching into classroom practice. Common themes along with differences in perceptions of science instruction will be identified. Recommendations will be made about structuring science methods courses and student teaching field experience to improve preservice science teachers' professional preparation.

15.09

THE DEVELOPMENT OF PRESERVICE TEACHERS" CONTENT KNOWLEDGE IN AN INTEGRATED TEACHER PREPARATION PROGRAM

Timothy J. Breen, Joseph S. Krajcik, and Brian P. Coppola, University of Michigan

This study documents the content knowledge of preservice elementary school teachers, investigates the development of their knowledge over the course of a year, and explores possible reasons for this development. The preservice teachers were involved in a unique yearlong integrated teacher preparation program designed to enhance their ability to teach science. Semi-structured interviews were given before and after both the chemistry course and the physics course. The interviews will be coded and compared. The results will be related to unit design preparation, teaching experiences, and previous science coursework. The initial findings suggest that this type of integrated preparation program can help the development of scientific understandings among preservice elementary school teachers.

15.09

TEACHER-DEVELOPED LOCAL CURRICULUM PROJECTS ON WATER-RELATED ISSUES: A FORMATIVE EVALUATION

William S. Carlsen and Christine M. Cunningham, Cornell University

This poster summarizes an in-progress formative evaluation of eight school-specific science curriculum projects. Following an Eisenhower-sponsored summer institute on water quality and watershed dynamics, teams of secondary biology, earth science, chemistry, and physics teachers developed local water resource projects. These projects focus on local water problems and use an array of contemporary scientific techniques, including remote sensing, aquatic monitoring technologies, statistical analysis, and computer simulation. Institute staff are monitoring revisions and implementation of these curricula through school-site visits and regular communication with teachers via a statewide computer network. We identify factors that appear to promote or hinder curriculum implementation relative to teacher teams' own goals and the overall goals of the summer institute. The viability of local, cross-science projects should be of special interest to science

15.09 CARLSEN CONTINUED

educators because they are being undertaken in a state (New York) where bureaucratic requirements (state syllabi, rigid subject-matter boundaries, and frequent standardized testing) tend to constrain curricular innovation.

15.09

A STUDY OF SECONDARY AND ELEMENTARY STUDENT TEACHERS' CRITICAL THINKING, REFLECTIVE TEACHING, G.P.A., AND NTE SCORES

Josephine M. S. Desouza, University of Toledo, Toledo.

The study will be conducted in Spring and Fall 1992, and Winter of 1993. A. It examines the relationship among the critical thinking, reflective teaching, G.P.A., and NTE scores of secondary and elementary teachers. B. It compares the critical thinking ability of secondary student teachers of science, math, social studies and English methods. C. It examines the difference in secondary and elementary student teachers' G. P. A., critical thinking, reflective teaching ability. D. It also examines whether secondary and elementary student teachers' scores on critical thinking, reflective teaching and G:P.A. are predictors of their NTE scores. Findings of the study will be useful to teacher educators.

15.09

AN INVESTIGATION OF THE EFFECTS OF A HIERARCHICAL CONTENT MAPPING TECHNIQUE ON THE LESSON PLANNING PROCESS

Thaddeus W. Fowler, University of Cincinnati

An investigation is underway to study the impact of a hierarchical content mapping technique on the quality of lesson plans produced, which need to conform to a variety of teaching models and instructional approaches. It has been tentatively established that by separating categorical content (concepts) from functional relationships and by mapping each type of content independently using a strict hierarchical approach, a comprehensive and accurate representation of a body of knowledge is likely to be produced. It appears that clearer and more precise lessons are produced as a result of using this form of content mapping. The examples and non-examples presented in deductive and

15.09 FOWLER CONTINUED

inductive lessons better show the critical attributes of a concept and better represent the range of a concept. Similarly, functional relationships are better illustrated. Advance organizer lessons develop more easily by proceeding down through a concept or functional relationship hierarchy. Other instructional approaches are also positively affected.

15.09

CAN MID-CAREER CHANGERS ADAPT TO THE SCIENCE CLASSROOM? LETTING CASES TELL THE STORY

Sharon Lynch, Juliana Taymans, and Elizabeth McNerney, The George Washington University

There is currently a national shortage of qualified science and mathematics teachers. The down-sizinq of the military and concomitant cutbacks in personnel in related industries creates a promising pool of new science and mathematics teachers. the **mid-career changers**. The George Washington University has provided teacher preparation programs for this group since 1985. A primary concern, however, is the ability of mid-career changers to successfully adapt to the dynamics of the American public school classroom. The evolution of the beginning teacher's perspectives as she or he progresses through the student teaching internship is the focus of this paper. Three cases written by mid-career changers during their student teaching experience will be presented. The case writing procedure follows the methods developed by Shulman and consists of a structured three session format. Formal reactions to the cases are included, as well as a summary of the salient issues regarding mid-career changers ability to adapt to science classrooms.

15.09

COMPARISON OF SCIENCE TEACHING EFFICACY SCORES OF PRESERVICE ELEMENTARY TEACHERS IN A SIX WEEK SUMMER SESSION VERSUS A SIXTEEN WEEK NON:SUMMER SESSION

George E. O'Brien, Florida International University, and
Joseph M. Peters, University of West Florida

15.09 O'BRIEN CONTINUED

The purpose of the study was to compare the effects of a six week summer session versus a sixteen week non-summer session on the science teaching efficacies of preservice elementary teachers enrolled in the science methods course. Two instructors, using the same syllabus, with 9 classes and 193 students participated in the study. Both sessions included lessons with emphasis on hands-on science, cooperative learning, problem solving, and concurrent field-based experiences. Subjects were pre- and post-tested with the Science Teaching Efficacy Belief Instrument. Preliminary analyses of the data indicate effectiveness during both sessions in increasing efficacy scores.

15.09

PERCEPTIONS OF SCIENTISTS AMONG PRE-SERVICE AND EXPERIENCED ELEMENTARY SCHOOL TEACHERS

Melanie A. Reap, Ann M.L Cavallo and Lisa McWhirter, The University of Oklahoma

The study explored the nature of pre-service and experienced elementary teachers' images of scientists and possible shifts in pre-service teachers' images of scientists after taking a science methods course that implemented Learning Cycle methodology and promoted a multicultural view of science. The Draw-A-Scientist test was used at the beginning of the methods course and was repeated at the end of the course. The experienced teachers were given the activity one time only during summer course work. Results of pre and post methods course drawings indicated there were general shifts among the pre-service teachers' drawings to a less stereotypical view of scientists. The experienced teachers' drawings were similar in nature to the pre-service teachers' first day of class drawings, with many depicting common stereotypes.

15.09

PREPARING ELEMENTARY TEACHERS FOR EFFECTIVE SCIENCE TEACHING IN DIVERSE SETTINGS

Iris M. Riggs and Joseph Jesunathadas, California State University, San Bernardino

The impact of a National Science Foundation supported training on elementary teachers' beliefs, attitudes, and behaviors related to teaching science in diverse settings was studied. Findings from analyzed pre/post belief and attitude assessments, teacher journals, classroom observations, and student attitude and achievement in science will be reported.

15.09

COMMUNITY CONCEPTUAL CHANGE: CONSENSUS SHAPING THROUGH PERSUASIVE DIALOGUE

Joseph P. Riley and J. Randy McGinnis, University of Georgia

This research in progress examines a social constructivist approach to conceptual change. The perceived persuasive nature of the interaction among a community of learners and its contribution to conceptual change is the focus of the study. An analysis of student to student dialogue before, during, and after ideational confrontation is the primary data source. Participants were 31 preservice teachers enrolled in two different sections of an elementary science methods course. The study consisted of five phases: A. Participants responded to the statement, **For every action there is an equal and opposite reaction** on a four item instrument; B. Participants were assigned to focus groups that represented the same item choice and, thus, shared analogous alternative frameworks. In groups, students discussed their reasons for selecting the responses which were tape recorded; C. Tapes were collected and distributed to different groups. Their reaction to listening to the tapes was videotaped. Each group listened to all tapes; D. Instruction followed which consisted of film loop, lecture, and discussion components; and, A whole class discussion was conducted with the instructor acting as a negotiating agent. Tentative findings indicate student persuasion was the primary factor in changing student conceptions.

15.09

CHANGE IN PRESERVICE TEACHER BELIEFS ABOUT ELEMENTARY SCIENCE TEACHING

Carla Zembal, Mary Starr, Joseph Krajcik and Annemarie Palincsar,
The University of Michigan

This study used pre- and post-inventory data from two teacher belief inventories. One belief inventory was on general beliefs about teaching. The second inventory was on science teacher beliefs. Teacher belief interviews to examine changes in beliefs of preservice teachers as they progress through an integrated elementary science teacher preparation program were also used as data. Initial analysis of the data shows that changes in teacher beliefs of these preservice teachers occurred primarily in the area of beliefs about science instruction, especially with regard to assessment and the organization and structure of instruction. In addition, the changes observed were in the desired direction of program themes. Because of the longitudinal nature of the three year teacher preparation program, additional teacher belief data will be collected from preservice teachers at critical points during their professional development. As preservice teachers gain more classroom experience, it is expected that their beliefs about teaching will also change.

19.1

PREPARING ELEMENTARY EDUCATORS TO TEACH SCIENCE: AN EXAMINATION OF A PILOT TEACHER PREPARATION PROGRAM

Kathie Black and Priscilla Norton, University of New Mexico

This study explored the impact of a pilot program for elementary education science teachers. The pilot group participated in four credit hour classes designed to cover content while simultaneously modeling teaching practices associated with good science education. Predicated on the notion that **we tend to teach the way they are taught**, the pilot program uses students' content learning experiences as a springboard to a vision of science instruction which diverges from traditional lecture/demonstration practices. Emphasis is on experiencing science learning through the learning cycle, inquiry learning, and an interdisciplinary science and society approach. The pilot group was compared to a science methods class whose course work consisted of traditional science content courses. The groups were compared on measures of science knowledge, attitudes toward science, and ratings of how important and how often they thought they would use a set of identified instructional strategies. No significant differences were found related to science knowledge and attitudes toward science. Differences were found related to beliefs' about the importance and frequency of instructional strategies.

19.10

GROW IN SCIENCE: SCHOOL DISTRICT, COMMUNITY COLLEGE, AND UNIVERSITY COLLABORATION ON IN-SERVICE ELEMENTARY TEACHER EDUCATION

David E. Brown, University of Illinois
Marilyn R. Sinclair, Champaign School District, and
Andrew Holm, Parkland Community College

We describe a summer course for elementary teachers designed collaboratively by representatives from a school district, a community college, and a research university. In the course we engaged teachers to reflect on a constructivist perspective on learning through a coherent constructivist approach. We did not consider it possible to simply transfer to teachers (e.g. in the form of curricular materials with instructions for use) an improved ability to engage students in fruitful inquiry. Just as students need to explore phenomena, teachers need to explore learning in inquiry oriented situations. This course was designed to provide teachers with such experiences, first from the perspective of a learner, and then from the perspective of a teacher in a summer science camp. Largely qualitative data sources include notes and videotapes of course discussions and inquiry activities with the teachers, video data focusing on small groups of children during the summer camp taught by the teachers, and copies of teachers' reflection papers and interpretive diaries focusing on their own and the children's learning. These data indicate significant growth in both the teachers and the children's' abilities to engage in fruitful inquiry and in teachers' abilities to structure classroom environments to encourage inquiry.

19.10

REFLECTIVE PROBLEM SOLVING: LEARNING-TO-TEACH ELEMENTARY SCHOOL SCIENCE AND MATHEMATICS

Carol L. Stuessy, Texas A&M University, and
Stephanie L. Knight, The University of Houston

The context for the study was an innovative teacher preparation course that integrated methods for teaching elementary mathematics and science, a prototype for the Teachers As Reflective Problem Solvers (TARPS) constructivist model for the preparation of teachers. In this study, the roles of reflective and problem solving processes in 35-preservice elementary teachers were explored. Three research questions were investigated regarding:(a) patterns of change in preservice teachers' reflections; (b) the relationship between reflection and problem solving abilities; and (c) the correspondence between preservice teachers' perceptions of their abilities as reflective problem solvers and their actual performance. Performance-portfolios,documented students' performance and reflections. Pre- and posttests of the Group Procedural Skills and Abilities Self-Evaluation Questionnaire (GPSAEQ) were compared to students performance-portfolios. Results suggested a pattern of change in students' reflections during the semester. Interactions between problem-solving performance and reflection were observed for some problem-solving processes, and discrepancies were found between students' perceptions and actual problem-solving performance.

19.13

MULTIPLE LEARNING SITES: FLEXIBILITY IN THE TEACHING PROFESSION

Gary Habib and Hedy Moscovici, The Florida State University

The study centered around a teaching and learning course designed for prospective elementary school teachers. One of the course goals capitalized on the students' images of having flexibility in choosing appropriate learning settings. This was interrelated with various approaches in diverse contexts. Multiple learning settings/sites were identified by the students and the instructors as potential alternatives to the typical classroom setting. The signs and symbols in each were discussed. Advantages and disadvantages in each setting were looked at

19.13 HABIB CONTINUED

for similarities based on students' experiences.The various components that comprised their image were analyzed using a semiotic perspective. Interactions among the instructors' and the prospective teachers added to a deeper understanding of all the participants' beliefs regarding learning settings. The flexibility in selecting a specific learning site was deliberated. Another example of flexibility was the continuous change in the course syllabus during the semester. The instructors were active participants in all the activities. The purpose was to understand how flexibility enables the teachers to be aware of students' needs and to work together with the students for the students. The element of flexibility enabled the participants to be learners.

19.13

VARIOUS MEASURES OF PRESERVICE TEACHERS' SCIENCE KNOWLEDGE AND SKILLS

John Settlage, Jr., Cleveland State University
Lloyd H. Barrow and Julie Cook Southwestern Bell Science Education Center, University of Missouri.

Preservice elementary education majors were evaluated for their science knowledge and skills using four different instruments. Ability to apply science process skills was measured with items from the performance based SISS process test, Piagetian development was determined with the GALT, and science knowledge was evaluated using student scores on the C-BASE Science and the ACT Natural Science tests. Statistically significant correlations were found between the students' C-BASE Science scores and the other three instruments. A strong correlation was also found between performance on the SISS process items and the GALT. These results indicate that the use of the C-BASE as a factor in determining admission to the university's teacher education program has merit, although other criteria should be considered in conjunction with the use of test scores.

21.13

INFLUENCE OF COOPERATIVE EARLY FIELD EXPERIENCE ON PRESERVICE ELEMENTARY TEACHERS' SCIENCE SELF-EFFICACY

John R. Cannon, University of Nevada-Reno
Lawrence C. Scharmann, Kansas State University

The influence of cooperative early field experience on preservice elementary teachers' science self-efficacy was investigated in this study. The population was comprised by 121 preservice elementary education students enrolled in an elementary science methods course. Cooperative learning groups were formed within each of five laboratory sections. Each cooperative group witnessed several modeled science lessons employing cooperative techniques prior to planning and teaching a cooperative elementary science lesson in local public schools. Science teaching self-efficacy scores were obtained from two laboratory sections directly before and three other sections immediately following the performance of a cooperative teaching field experience. An ANOVA was conducted; a significant main effect was obtained ($F = 8.63$; p c 0.01) with respect to time of self-efficacy assessment. This finding supported an inference that early cooperative field experience had a positive influence on preservice elementary teachers' science self-efficacy.

21.13

SCIENCE TEACHER EFFICACY, LOCUS OF CONTROL AND SELF CONCEPT OF AUSTRALIAN PRESERVICE ELEMENTARY SCHOOL TEACHERS

Keith B. Lucas, Ian S. Ginns, David F. Tulip, and
James J. Watters, The Centre for Mathematics and Science Education,
Queensland University of Technology, Australia

In a study of the characteristics of commencing undergraduates in a 3-year preservice Bachelor of Teaching (Primary) degree program at a large Australian metropolitan university, reliability coefficients for the Science Teacher Efficacy Beliefs Instrument-B (STEBI-B), the Dimensions of Self Concept - Form H (DOSC-H) and the Academic Locus of Control for College students (ALOC) were determined. They were found to

21.13 LUCAS CONTINUED

be similar to those presented by the developers of these instruments in American contexts, thereby indicating that they may be used in Australia with some confidence. Furthermore, substantial confirmation of predicted intercorrelations between scales of the three instruments provided additional evidence of the criterion-related validity of the scales. The study suggests that further research is required on the nature of the interrelationship between science teaching outcome expectancy (STEBI-B) and self concept (DOSC-H).

21.13

A COMPARISON OF MIDDLE AND JUNIOR HIGH SCIENCE TEACHERS LEVELS OF EFFICACY, PERCEPTIONS OF SUPPORT, AND KNOWLEDGE OF DEVELOPMENTALLY APPROPRIATE CURRICULUM AND INSTRUCTION

Martha Schriver, Georgia Southern University

This study compared the relationship among levels of personal and professional teaching efficacy, perceptions of support and knowledge of developmentally appropriate curriculum and instruction for middle and junior high science teachers. Research has indicated that teachers perceptions of their efficacy affect what and how they teach. Furthermore, organizational aspects promoting collegiality and decision-making have enhanced teachers level of efficacy. This study s sample consisted of 120 seventh and eighth grade science teachers from 80 schools in Ohio. Data was obtained from questionnaires measuring efficacy, support and knowledge of developmentally effective curriculum and instruction. Data was analyzed using t-tests and regression equations, resulting in conclusion concerning both personal and professional teaching efficacy. Professional efficacy was found to be strongly related to knowledge of developmentally effective curriculum and instruction. Also, specific evidence indicated that the level of support for middle school teachers with secondary certification was related to science teachers perceptions of support.

21.14

A METAPHORICAL ANALYSIS OF SCIENCE LESSONS IN A MIDDLE SCHOOL CLASSROOM: MAKING MEANING IN THE MARGINS OF INSTRUCTION

Ann Haley-Oliphant, Miami University, Oxford, Ohio

This paper reports on a study of science instruction where the teacher accomplishes many of her subject matter learning goals by departing from the centers of lessons to the margins created by conversations and activities not usually considered to be on-topic or pedagogically oriented. The nature of these interactions and how they promote learning is interpreted using the ecological metaphor of margins as places for preserving diversity and fostering change in students' understandings of the content.

22.13

ORIGINS OF LIFE SCIENCE TEACHERS' BELIEFS UNDERLYING CURRICULUM CHANGE: PROBING THE THEORY OF PLANNED BEHAVIOR

Frank E. Crawley and Barbara Salyer Babineaux, Science Education Center,
University of Texas at Austin

The purpose of this study was to identify the beliefs that serve as the foundation for grade 7 life science teachers' intentions to implement integrated, thematic science activities in the classes they teach and to investigate the origins of these beliefs. An empirical model for investigating rational decision-making, the Theory of Planned Behavior, was adapted for data collection. Participants were middle school teachers from a variety of school districts in central Texas. Four data sources were used, including an in-depth interview protocol. Eight assertions were generated. The Theory of Planned Behavior provided an effective model for structuring an interview protocol. Some teachers found it difficult to articulate their beliefs as well as the origins of these beliefs. They came to and then extended the boundaries of their understanding of the reasons they were participating in curriculum change. Teachers seemed to engage in a form of self-persuasion which served to bolster their commitment to change.

22.13

CHANGE IN ELEMENTARY SCHOOL TEACHERS' PRACTICES IN SCIENCE

Susan J. Doubler, TERC

This research explores the dynamics of teacher change. It pertains specifically to science teaching at the elementary school level and follows individual teachers for three consecutive years in order to understand their experience with change and to identify effective means of supporting desired change. Central to the study is a consistent model for teaching and learning. The model serves a pivotal role in the study. It establishes the theoretical groundwork, provides a master scheme for intervention with teachers, serves as a guide in determining data collection strategies and provides the backdrop for the analysis. Findings suggest that when teachers make effective change they often become more reflective, pay more attention to children's ideas, move away from right and wrong thinking in their teaching, change the kind of questions they ask and are more critical of what they do and the materials they use. Findings also suggest that teachers approach change in different ways, at different rates and from different starting points; what helps one teacher may not always helpful to another.

22.13

PROFESSIONAL DEVELOPMENT OF SCIENCE TEACHERS: TEACHER INVOLVEMENT IN PLANNING

Katherine Norman, The University of Wisconsin-Stevens Point

Research on adult learners, staff development, and teacher change has emphasized the importance of involving teachers in all phases of program planning. This paper focuses on the processes followed when teachers planned a summer staff development program and the results of that planning. The teachers' post-workshop ratings of the sessions of the program are also discussed. On the evaluation instrument, the teachers rated the usefulness and the interest of each of the sessions and they rated their own confidence and knowledge levels before and after the summer workshop. Sessions on sharing resources, outdoor investigations, and integrating environmental education were rated highest in both interest and usefulness. According to the teachers' ratings of their knowledge and confidence, they

22.13 NORMAN CONTINUED

experienced increases in both dimensions following participation in the workshop. There was a significant difference in the teachers' pre-workshop knowledge and confidence levels and their post-workshop knowledge and confidence levels. The teachers gained the most knowledge about writing grant proposals, using the learning cycle, using games to teach environmental concepts, and selected ecosystems. They gained the most confidence in developing environmental education investigations using the learning cycle, teaching lessons by inquiry/discovery, and integrating environmental education into traditional subjects.

22.14

AN EXAMINATION OF THE SCIENCE LITERACY OF SCIENTISTS AND SCIENCE EDUCATORS

Dennis Showers, The State University of New York at Geneseo

This study develops a model for identifying and quantifying science literacy for the purpose of guiding science education policy and, ultimately, resource allocation. The model is tested by attempting to distinguish groups who possess science literacy so as to identify their background and experiences that result in literate behavior. A survey of scientists and science educators provided data that show these groups 1) do not have high levels of content knowledge outside their area of professional expertise, 2) do not vote based on understandings of the scientific dimensions of public issues, 3) have significant beliefs in superstition and pseudoscience, and 4) make personal and social choices based on non-scientific aspects of decision-making situations. The author suggests that the pursuit of science literacy is an admirable, but impractical goal and distracts resources that could be used to assure a well-prepared scientific work force that includes females and minorities.

22.14

VIEWS OF PROSPECTIVE-TEACHERS VERSUS PRACTICING-TEACHERS ABOUT SCIENCE, TECHNOLOGY AND SOCIETY ISSUES

Uri Zoller and David Ben-Chaim, Haifa University-Oranim, Israel

The science-technology-society (STS) views/positions, beliefs/attitudes, and literacy of social studies and science prospective teachers and of practicing secondary school social studies and science teachers have been assessed and their respective STS views, beliefs and literacy profiles established by the use of a shortened version of the Views of Science, Technology and Society (VOSTS) inventory instrument. Significant differences were found between the STS views, beliefs and literacy profiles of subgroups within prospective and practicing teachers in the views/positions and the beliefs/attitudes categories. In contrast, no differences were found between the profiles of the subgroup populations in literacy category. In recognizing (a) the key role of teachers in any curricular reform; (b) the need of integration of the STS theme in contemporary and future education for all; and (c) the alterable nature of the personal STS views, it is recommended that appropriate teacher training programs should be designed and implemented in order to attain with students, through their adequately prepared teachers, the intended goals of STS education.

22.14

CONCEPTUALIZING A TEACHING EXPERIENCE ON THE DEVELOPMENT OF THE IDEA OF EVOLUTION: A BROAD EPISTEMOLOGICAL APPROACH TO THE EDUCATION OF SCIENCE TEACHERS

Ruth Zuzovsky, Tel Aviv University and State Teachers College

This paper will describe and discuss an epistemological approach to the education of science teachers, which emphasizes similarities in knowledge and modes of acquiring it among children, scientists in their historical contexts, and between student teachers. Advanced courses in science teacher education aim to go beyond the attainment of scientific knowledge and pedagogical content knowledge toward the building of a guiding theory of action for teaching. This theory needs to be rooted in a broad understanding of what science is about, what is regarded as scientific knowledge and how it is generated and evolved.

22.14 ZUZOVSKY CONTINUED

These questions are of an epistemological nature. At the same time, theories of action for teaching science are also connected with questions on individuals' ways of learning and of acquiring meaning. Such questions are often answered by cognitive psychologists and developmental psychologists. Even here epistemological considerations are essential. Constructivist epistemology, which describes the process of constructing knowledge both in individuals and among scientists, can serve as a basis for generating such a guiding pedagogical theory of teaching. Educating science teachers in the light of radical versions of constructivism can enhance this process. This paper discusses the possibility of adopting constructivist epistemological approaches to science teacher education and presents an example of this approach.

24.02

ENHANCING UNDERGRADUATE STUDENT LEARNING OF CELL BIOLOGY: MOVING AWAY FROM THE LECTURE PODIUM

Jolie Mayer-Smith, University of British Columbia, and
Barbara Moon, Simon Fraser University

A collaborative research project investigated student learning of cell biology concepts in a first year biology majors course. It was postulated that student learning difficulties were linked to passive learning in lecture based classes. The effects of implementing generative learning strategies were studied. Student conceptions of cell biology were collected by written probes, concept mapping, and interviews. Traditional lectures were preceded by systematic, open ended discussions in small groups. Pre-lecture discussion questions were designed based on concepts known to be difficult for undergraduate biology students. A model of student conceptions about cell functions was developed. The effectiveness of the strategies was assessed by comparing tests results of the experimental group with those of a comparison group.

24.07

BRIDGING EXPLANATIONS, DISCUSSION, WORKED EXAMPLES, REMEDIATION AND THEIR EFFECTIVENESS AS TEACHING STRATEGIES IN A FRESHMAN-LEVEL NONSCIENCE MAJOR CHEMISTRY COURSE

Diana Mason and Frank E. Crawley, The University of
Texas at Austin

This study was undertaken to establish the effects of four teaching strategies on student achievement regarding chemical bonding. The methodology employed in this study was quasi-experimental, since the 108 students were self-selected for the eight different subgroups, and causal-comparative by nature. The main objective of this study was to determine the benefits and drawbacks for each experimental strategy. Worked examples proved to be the least effective method for improving student performance. Bridging explanations were best when addressing a narrow range of instructional material, but lacked application when applied to the broader scope. Review of remedial concepts were the most effective in improving individual performance. Student-led discussions had the most positive long-term influence on student performance. From collected student responses, the most frequent explanation given for knowing why an answer to a particular problem was correct (or incorrect) was that a specific definition had been memorized.

24.13

PRESERVICE BIOLOGY TEACHERS' CONCEPTIONS OF TEACHING SCIENCE: WHAT ARE THEY? DO THEY CHANGE? WHAT INFLUENCES THEIR CHANGE?

Perry Allen Cook, University of North Dakota

A qualitative, descriptive investigation into conceptions of teaching science held by five preservice biology teachers in a constructivist methods and practicum. The study examined their initial and exit conceptions of teaching science, changes in their conceptions and influences on those changes from methods and practicum. Major data sources included: Two sets of Conceptions of Teaching Science interviews concerning beliefs about science, learning, instruction and science teaching; two sets of Influence Interviews about significant methods and practicum experiences influencing evolving views and

24.13 COOK CONTINUED

journals. Some teachers' initial science views were fragmented-stressing science was everything. Exit views represented more conceptual understandings of science. Learning views changed from independent, constructivist understandings to conceptual change, learner dependent models. Instructional views shifted from content presentation and question asking to incorporating conceptual change models of learning, making content relevant and developing critical thinkers. One teacher's thoughts about science teaching shifted from didactic, presentation beliefs to more learner centered, relevant views. The results suggest important changes did occur in preservice biology teachers' conceptions of teaching science enrolled in a constructivist methods and practicum.

24.14

THE USEFULNESS OF CONCEPTUAL CHANGE CONSTRUCTS IN PROMOTING PEDAGOGICAL METACOGNITION IN PRE-SERVICE ELEMENTARY SCIENCE METHODS CLASSES

Mary Lee Martens, State University of New York, Cortland

The Conceptual Change Model is used widely as a tool in assessing students' understandings of science concepts. There is little documentation, however, for its use in teacher education or in academic areas other than math and science. This interpretive study examines the relationship between students' beliefs about teaching and learning science and pedagogical experiences provided in an elementary science methods class. Findings: l) Few students have difficulty negotiating evidence for or demonstrating conceptual change whose status is intelligible or plausible, 2) Non-traditional students are more willing to establish criteria for learning that is fruitful than younger, less experienced students who feel that this can only be demonstrated after they begin to teach, 3) Although the course provided students with traditional learning experiences, many use only schema developed through years of lecture and textbook instruction in their reflections.

24.14

PRESERVICE TEACHERS' LEARNING OF CONCEPTUAL CHANGE PEDAGOGY: AN EXAMINATION OF THREE APPROACHES TO METHODS INSTRUCTION

Beth A. Wiegmann and Rene' T. Stofflett, Northern Illinois University

This study examined three different approaches to elementary science methods instruction and their relative impact on teacher candidates' preconceptions of science pedagogy. This research is part of a larger project to improve science methods instruction by developing a conceptual change teaching model. This qualitative study examined three science methods courses: A conceptual change approach, microteaching model, and a methods-text curriculum. The sample included 74 preservice teachers enrolled in three sections of a science methods course. Pretest and posttest data were collected using an open-ended 11 question instrument. Responses were coded by two researchers, interrater reliability was established, and a chi square analysis was used to evaluate categorical change from pretest to posttest. The results indicated that the highest level of knowledge reconstruction occurs when teacher candidates are given opportunities to experience the science teaching methods as content learners and have the opportunity to use the methods in actual practice. Both of these conditions occurred within the conceptual change teaching model, which led to the greatest amount of cognitive change in its teacher candidates.

27.03

ACT SCIENCE, C-BASE SCIENCE, COLLEGE SCIENCE HOURS, AND GPA: PREDICTORS OF PRESERVICE ELEMENTARY TEACHERS' ATTITUDES TOWARD THE TEACHING OF SCIENCE

Betty L. Bitner, Southwest Missouri State University

Scores on the science subtests of the C-BASE and ACT, number of college science hours, and college GPA were investigated as predictors of preservice elementary teachers' attitudes toward the teaching of science. The Science Attitude Scale for Preservice Teachers measuring comfort/discomfort of teaching science, science as a basic need, time required to prepare and teach science, and handling science equipment, was administered to the sample (N=212) during the first week of the

27.03 BITNER CONTINUED

elementary science methods class. The stepwise regression yielded all independent variables except life science hours as predictors of attitude toward teaching science.

27.12

TRANSFORMATIONS OF PRIOR EXPERIENCES AND SCIENCE METHODS INTO ELEMENTARY CLASSROOMS

Belinda Duncan, Julie Gess-Newsome, and Trish Stoddart,
University of Utah

Prior research has shown that the influences of teacher education programs are often mitigated by personal perspectives and school context. However few studies have examined the effects of subject specific methods courses on content instruction. The purpose of the study is to describe how a science methods class taught by a single instructor influenced the science instruction of four elementary school teachers. The science methods class focused on Piagetian stages of cognitive development, the importance of science process skills, and computer software use in the classroom. The teachers, with an average of six years teaching experience, were interviewed about their perceptions of science, themselves as science learners and teachers, the school context for teaching science, and the specific influence of their science methods course on classroom practice. Classroom observations were conducted to validate information provided in the interviews. The teachers viewed science as exclusively content topics which are best learned through hands on methods. Such incoming beliefs obstructed their ability to adopt views of science as including process skills or to consider student developmental level when teaching science lessons. These findings support those found from generic methods instruction and demonstrate the importance of assessing and confronting preservice teachers' incoming science attitudes and beliefs.

27.12

PRESERVICE TEACHER CONSTRUCTIVISM: THEORY AND PRACTICE DIALECTIC

Scott Robinson, The Florida State University

The purpose of this qualitative descriptive study was to determine how preservice teachers adapted constructivism into practice. The three major research questions were: a. What effected preservice teacher epistemology? b. How well did constructivism translate into classroom practice? c. What was the nature of the linkages between epistemology beliefs and the field practices? Campus based epistemology courses promoted constructivism. Preservice teacher interviews and classroom observations were conducted during the student teaching field based experience. Preservice teacher self-resistance and classroom experimentation incorporating the constructivist paradigm were identified. Preservice teachers reflected upon the adaptability of constructivism in the secondary science classroom. Constraints originating within both campus based instruction and secondary school settings were presented. Variables effecting linkage of the theory and practice dialectic were proposed. Science teacher education program modifications were suggested.

27.12

A SYMBOLIC INTERACTION STUDY OF SCIENCE TEACHERS: RELATIONSHIPS

Meta Van Sickle, University and College of Charleston

The purpose of this study was to identify what was happening in three classrooms with science teachers who were perceived to be caring and implementing goals promoted by national science education reform movements. The research was completed using the qualitative research tradition symbolic interaction. This research tradition was used to generate categories of identifiable behaviors carried out in these science classrooms since the notable characteristic of caring has not previously been studied. Other related content areas, such as mathematics, have begun studies on caring in the classroom. The first category to emerge was relationships. The forms of relationships identified in these science classrooms were teacher and student, student and student, teacher and content, and teacher, student, and

27.12 VAN SICKLE CONTINUED

content. Each of these teachers took time to make sure the content, the student, and the teacher interconnected, or related, in order to make learning meaningful. All the data sources confirmed that these three science teachers believed that relationships were an important part of caring in their classrooms.

27.13

A FORMATIVE EVALUATION OF A SCIENTIFIC WORK EXPERIENCE PROGRAM FOR SCIENCE TEACHERS

Sandra Gottfried, University of Missouri-St. Louis

The study was a formative evaluation of a scientific work experience program for science teachers. During a six week summer program, science teachers conducted research with faculty members at the University of Missouri-St. Louis in the departments of biology, chemistry and physics. Since more than 85 scientific work experience programs now exist in the United States, the findings from this study may provide direction for assessing teacher change as the result of participating in this type of teacher inservice program. The Test of Integrated Process Skills was used following a one-group pretest-posttest design. An analysis of the data revealed no statistically significant difference between the pretest and posttest scores. The Science Classroom Activity Checklist was administered following the same design. Analysis of the data revealed no significant change regarding behaviors of the teacher, behaviors of the students, or the nature of the use of textbooks, tests, and other materials in the classroom. However, teacher-reported data from questionnaires revealed that teachers perceive somewhat substantial changes in these areas.

27.13

THE EFFECTS OF A WORLD IN MOTION CURRICULUM ON SELECTED STUDENT OUTCOMES

Mike Nelson, University of Kansas

The study examines the effects of a summer teacher workshop implementing A World in Motion (AWIM). In this study, student achievement on a process skills test was the focal outcome. AWIM is a fourth-sixth grade investigation-based program developed by The Society for Advancing Engineering (SAE). AWIM pairs engineers with teachers to provide students a role model and to share applications of the physical science processes and content. In the three week summer workshop, the teachers completed each of the 15 AWIM major investigations, learned to transfer their team data to a database format, and constructed process skill questions. These questions guided the development of the **A World In Motion Inventory** (AWIMI). In the fall of 1992, the teachers and fifth through sixth grade students participated in the validation of AWIMI. Students' mean differences on AWIMI were used to assess the effects of the A World in Motion program on students' achievements of the identified process skills. A Solomon Four-Group design was used to examine the students' outcomes. Item analysis and a reliability index were used to support this study.

27.13

EFFECT OF RESEARCH EXPERIENCES ON TEACHERS' PERCEPTIONS OF THE NATURE OF SCIENCE

Suchin Visavateeranon, Fred Finley and Douglas Huffman, University of Minnesota

The purpose of this study was to examine inservice teachers' perceptions of the nature of science before and after research experiences with university faculty. Thirty-one secondary and elementary science and social science teachers engaged in research projects with university faculty for 2 to 4 weeks. Teachers' perceptions of the nature of science were examined before and after the research experiences with the Nature of Science - Key Features Test, lesson plans, journals, and interviews. Results of the study indicate that the research experiences appeared to affect teachers'

27.13 VISAVATEERANON CONTINUED

perceptions of the nature of science, but in a limited way. Initially, teachers' views were a combination of traditional and modern views of the nature of science. Alter the research experiences, approximately 25% of the teachers changed their views about selected aspects of the nature of science from traditional to more modern beliefs.

28.1

LEARNING FROM TEACHING: SOCIAL CONTEXT ISSUES IN CONCEPTUAL CHANGE SCIENCE TEACHING

Sandra Abell, Purdue University,
Kathleen Peasley, and Kathleen J. Roth, Michigan State University, and Deborah Smith, University of Delaware

Each of the researchers in this symposium have explored the implications of conceptual change research for classroom teaching through research on their own teaching of science in elementary school classrooms. In this symposium each researcher will present a classroom case drawn from research on her own teaching. The cases highlight a variety of social context issues that arise when a teacher attempts to use theoretical ideas drawn from the conceptual change literature to guide her planning and teaching. The cases (including vignettes and videotape segments) will be used to stimulate discussion about the relationships between conceptual change theory and classroom contexts. What are different images of what conceptual change teaching might look like in action?. What dilemmas and decision points arise during conceptual change teaching? An alternative format will enable participants to peruse the cases and questions ahead of time and to engage in small group discussions facilitated by the presenters. Discussant comments will focus on synthesis and implications for future research agendas.

TEACHING AND LEARNING COLLEGE SCIENCE

5.11

DEVELOPING PROBLEM-SOLVING SKILLS IN CHEMICAL EQUILIBRIUM -- A CONSTRUCTIVE MODEL

Mei-Hung Chiu, National Taiwan Normal University, ROC

The purpose of this research was to examine the problem solving skills of 10th graders' as they studied examples of chemical equilibrium that had been previously solved. The framework for this research effort were the three following questions: 1) How do 10th grade students learn from examples in solving chemical equilibrium problems? 2) What are the of learning behavior differences between **good** and **poor** students ? 3) How do constructive learning behaviors (i.e., self-explanations) subsequently enhance one's construction of knowledge for solving problems? The study was conducted in three phases: 1) a pre-test in which students' misconceptions about chemical equilibrium was covered, 2) studying materials in which it is contained with diagrams, examples, exercises and tables, and 3) an alternative version of pretest as a posttest. Extensive analyses of think-aloud protocols from my subjects reveal that the **poor** students used more surface features of examples to solve problems, while the **good** students understood the underlying principles in the examples and applied them appropriately. The finding also suggests that a major shortcoming of textbooks is a lack of sufficient information for solving problems.

7.03

WHAT MIGHT A THEORY OF CLASSICAL GENETICS LOOK LIKE

Robert S. Hafner, Western Michigan University

Knowledge of a discipline's structure is essential for selecting and organizing curricular content and designing effective instruction. Philip Kitcher has departed from the main philosophical traditions concerning the structure of scientific theories in advocating the biological theories of evolution and genetics as collections of problem-solving patterns aimed at answering families of questions. Representations (models) of the conceptual and procedural knowledge needed to solve realistic genetics problems have been derived from

7.03 HAFNER CONTINUED

expert/novice studies. These models and associated problems, in the context of Kitcher's view, collectively provide a representation of a theory of classical genetics. This paper will explicate that structure and its value in the solving of realistic genetics problems.

7.07

THE PROFESSIONAL DEVELOPMENT OF COLLEGE SCIENCE PROFESSORS AS SCIENCE TEACHER EDUCATORS

Patricia M. Fedock, William W. Cobern, and Ronald W. Zambo, Arizona State University

The purpose of the study was to examine, qualitatively, the personal development of four college science professors teaching a summer science academy for K-12 grades. The academy was designed to enhance a teacher's knowledge of science and instructional methods. The academy was sponsored by a National Science Foundation (NSF) grant, funded for the Comprehensive Regional Center for Minorities in a large metropolitan area. The academy focused on biological concepts and was divided into sections for elementary and secondary teachers. The instructors were science professors from the community college where the academy was held. The science professors, after visiting school classrooms and doing consultations with education specialists, designed the academy curriculum with instructional procedures. Since there are frequent calls for science professors to become involved with inservice teacher education and, since this was the first experience with teacher education for the professors, this academy provided an excellent opportunity to study the response of science professors to the challenge of teacher education. The analysis found that professors began with some anxiety but became enthusiastic while working with teachers. The professors are making changes in their college courses because of this experience. The research report concludes with recommendations for science professors' involvement with teacher education.

8.06

SCIENTIFIC INQUIRY: A BRIDGE

Carolyn B. Black, Incarnate Word College

This proposal outlines a three semester hour undergraduate, core course in Scientific Inquiry that increases student knowledge and advances student skills in understanding science as knowledge, process, and human enterprise. This required course in Scientific Inquiry provides a bridge between science and the humanities and a bridge for entry-level students in the development of attitudes and understandings of methods used in scientific research and enterprises. Scientific Inquiry as a core course provides students with a background in the historic, cultural, and philosophical position of science and distinguishes between science and technology. Student reasoning processes have a chance to develop as they gain a more immediate understanding of how science is done by actual experience with scientific problem statement, experimental design, data collection, data interpretation and the drawing of conclusions. Reading and interpreting primary and secondary source science writings and producing written and oral critiques and commentaries permit students to participate in various research models of scientific inquiry. Overviews of essential ideas and current challenges in physical, chemical, biological, geological and space science fields provide a broadened understanding of the scale and proportion of science and what scientists in these various fields do.

8.06

AN EXAMINATION OF VIEWS ABOUT SCIENCE-TECHNOLOGY-SOCIETY INTERACTIONS AMONG COLLEGE STUDENTS IN GENERAL EDUCATION PHYSICS AND STS COURSES

Cristine Schoneweg, and Peter A. Rubba, Penn State University

The purpose of the study was to examine and compare the views of college students about science-technology-society (STS) interactions prior to and after taking either a general education STS or Physics course. Two samples of convenience took part in the investigation, one consisting of 138 students enrolled in a STS course, and the other of 122 students enrolled in a physics course. Data were collected using 16 multiple-choice items selected from the VOSTS (Views on Science-Technology-Society) item pool, an

8.06 SCHONEWEG CONTINUED

empirically developed instrument, as a pretest and posttest. In order to allow for inferential as well as descriptive analysis of the data, a new scoring procedure was developed for the VOSTS items which categorized responses as Realistic/Has Merit/Naive and assigned them ordinal point values. The findings implied that general education physics courses should not be expected to help students develop appropriate understandings of STS interactions. Also, STS general education courses still have room for improvement if it is desired that they help students build appropriate views about STS interactions.

8.07

IMPLICATIONS OF CURRICULUM REFORM: DEVELOPMENT AND

Katherine M. Edmonson, Cornell University

This paper will report on the origins and process of curriculum change within a professional (veterinary medical) curriculum. Groups of faculty developed concept maps to redesign the entire curriculum; implementation is scheduled for the fall of 1993. Three courses have changed in anticipation of the larger reform, and the results of those changes will be discussed. Resources such as ongoing faculty development will also be discussed, and the author will argue that these experiences can be generalized to any curricular change, particularly for subjects that require synthesis and application of theoretical and practical knowledge.

8.07

THE ORGANIZATION OF THE KNOWLEDGE STRUCTURE FOR RESEARCH AND A NEW COURSE IN CONTROLLED ENVIRONMENT AGRICULTURE (CEA)

Joseph D. Novak, Cornell University

A course was designed for upper-level undergraduate and graduate students interested in understanding the requirements for growing ornamental and crop plants under controlled environment conditions. Coordinated with our design of a new CEA course is a research program targeted at better understanding the parameters limiting plant growth under CEA and also implications for the development of a Controlled

8.07 NOVAK CONTINUED

Environment Life Support System (CELSS) in conjunction with research being done at NASA. The larger objective of the total program is to utilize the same knowledge base constructed for the CEA course to inform the research program, and vice versa. To build the knowledge structure necessary for the CEA program, we began an analysis of relevant literature, representing the major domains of knowledge in the form of concept maps. Concept maps provide a highly explicit and concise form of knowledge representation. The concept maps also suggested areas where knowledge was incomplete or lacking and pointed toward needed new research. Vee diagrams were constructed to suggest research programs that might be useful to provide needed new knowledge.

10.04

THE PERCEPTIONS OF COLLEGE SCIENCE STUDENTS ON THE NEED TO ENHANCE THEIR AWARENESS OF SCIENCE CAREERS AND RELATED OCCUPATIONAL INFORMATION

Christian P. Clermont, Prince Georges County Schools, Maryland

College students often experience some level of uncertainty regarding their choices of academic major and career direction at the undergraduate level. For students who major in the sciences, course work in the discipline helps them develop their commitment to the discipline and the profession. This study examined whether undergraduate science students, who show an interest in science, demonstrate a concomitant interest in learning about the various scientific careers that are possible within the discipline and to pertinent occupational information. The study further examined the preferences college science majors have with regards to the manner in which undergraduate science programs can best fulfill their need for heightening their career awareness regarding scientific work. By using a validated measure for assessing the level of student interest in learning about scientific careers, it was found that college science students indicated a strong interest in receiving occupational information as it relates to their major field of study. This interest was perceived to be nearly as strong as their interest in receiving scientific information in their regular science courses. The study also

10.04 CLERMONT CONTINUED

provided evidence regarding the types of career-oriented programs that appeal to science students at the undergraduate level.

10.07

PROBLEM SOLVING IN COLLEGE BIOLOGY: USING METACOGNITIVE ORIENTED CUES IN A HYPERMEDIA ENVIRONMENT

Xiadong Lin, Nancy Green Glenn, and David Eichinger, Purdue University

To test the effectiveness of stimulating metacognitive processes during problem solving through the use of cues built into a Hypermedia based simulation, elementary education majors in a college-level biology course were divided into four groups: Three experimental and one control. Learners from all four groups received the same amount of instruction and proactive, in class, learning time spent on the content material to build prior knowledge and strategies required to solve the problem. The only differences among the three treatment groups were the types of cues that had been presented, either content specific, affective or metacognitive. It was hypothesized that students who engaged in metacognitive process rather than concentrating strictly on the problem content level, would significantly benefit in solving content specific and skill transfer problems. Preliminary data analysis indicates that the treatment groups receiving metacognitive and content specific cues were more effective problem solvers than the control and affective cues groups. It also shows that the metacognitive cues treatment group scored higher on the test of transference than did the content specific group.

12.07

OVER-COMING THE SPORTS-MENTALITY METAPHOR: ACTION RESEARCH AS A METAPHOR FOR CURRICULUM EVALUATION

George M. Bodner, Purdue University

This paper will use the experience of recent National Science Foundation (NSF)-sponsored curriculum projects in science, engineering and mathematics to probe the notion that our colleagues in science and mathematics fall into categories: (l) those who do not know how to begin the process of evaluating curriculum materials, and (2) those who

12.07 BODNER CONTINUED

have only a sports mentality metaphor for evaluation, in which one **team** must win while another loses. It will then examine whether action research provides an alternative metaphor for evaluation of curriculum materials that can provide the information necessary to create curriculum materials at the college/university level that will meet the needs of students in the early years of the 21st century.

12.07

THE EFFECTS OF AN INTENSIVE SUMMER LABORATORY INTERNSHIP FOR SECONDARY STUDENTS ON STUDENTS' UNDERSTANDING OF THE NATURE OF SCIENCE.

William F. McComas, The University of Southern California

The study -- in conjunction with a qualitative investigation by McArthur -- examines the role of a six to eight week university laboratory internship in developing the views of secondary students' with respect to the nature of science. Students were assessed using a newly redesigned gender neutral version of the Test of Understanding Science (TOUS) as part of a pretest/posttest research project. The TOUS provides a total score and there subscales (understanding about the scientific enterprise, about scientists and about the methods and aims of science). Any significant changes from pretest to posttest with respect to these scores will be examined in light of other variables such as gender, and length and type of laboratory internship. Positive findings provide support for the notion that experiences such as laboratory internships have the potential to provide students an accurate view of the nature of science thus recommending such experiences as teaching vehicles to acquaint students with aspects of the philosophy of science.

12.07

THE TRAINING NEEDS OF INTERNATIONAL TAs VS. U.S. TAs

Deborah Wiegand ,and Mark Tanner, The University of Washington

This paper addresses a research study that was constructed to analyze the training needs of international teaching assistants (ITAs) in a

12.07 WIEGAND CONTINUED

department of Chemistry at a major research institution. In order to assess the results of a discipline-specific training program designed for ITAs, quantitative and qualitative data were collected by means of standardized course evaluations, mid-quarter interviews of undergraduate students concerning the quality of instruction received, and interview data from U.S. and international teaching assistants. Statistical comparison of the standardized course evaluations found significant differences between the U.S. and international TAs in nine categories of TA performance. Data gathered from the interview data proved valuable in identifying instructor characteristics, instructional methods, language skills, and aspects of evaluation which students found helpful in general chemistry laboratory sections. Based on the analysis of the data, revisions were made in the content and structure of the Chemistry department's ITA training program.

15.07

THE EFFECT OF TAXONOMIC RULES ON COLLEGE STUDENTS' PERFORMANCE IN NAMING/IDENTIFYING GENERAL CHEMISTRY COMPOUNDS.

Moises Camacho, IAU, Puerto Rico

This study investigated the ability of 75 science college students to identify and name simple general chemistry compounds whose nomenclature is covered in general chemistry I. A preliminary pilot study was made with about 100 students from which the 75 subjects were pooled. By using the think-aloud interview and a simple test. It was shown that almost all subjects lacked basic knowledge of the classes and nomenclature of general chemistry compounds. The nature, classification, and taxonomic rules were taught and practiced with 3 experimental groups. Group 1 had completed one semester of general college chemistry, group 2 had completed four courses of college chemistry, and group 3 had completed three courses of college chemistry. At the end of the semester a simple test was administered in which the mean scores were respectively 26.0, 36.0, and 26.0 for groups 1, 2, and 3. The two control groups had mean scores of 9.2 and 9.3.

15.07

STUDENTS' DIFFICULTIES APPLYING THE BRONSTED-THEORY TO ACID-BASE REACTIONS

Hans-Jurgen Schmidt, University of Dortmund

The purpose of this descriptive study was to uncover how senior high school students interpret the term **acid-base pair**. Within the scope of the investigation multiple-choice questions with distractors that reflect students' misconceptions were to be developed. A sample of 4,291 senior high school students of grades 11-13 completed multiple-choice tests. The students were asked to give reasons for their answers. Additionally, an individual class was interviewed on video while solving one of the tests. The results of the study show why students chose distractors rather than correct answers on multiple choice tests. Two factors were identified, the application of wrong theory and confusion about electron and proton transfer.

15.08

STRATEGIES AND SKILLS EXHIBITED BY COLLEGE STUDENTS DURING LABORATORIES IN FIRST YEAR PHYSICS

Laura M. Barden, and Michael D. Pugh, The University of Tennessee, Knoxville

The focus of much of the research concerning school science laboratory activities has been on either comparing laboratory formats using student achievement as the criteria or comparing the ways novices and experts solve problems. Seldom have the strategies that students employ while conducting a laboratory been examined. This study was designed to investigate the types of cognitive and metacognitive strategies exhibited during laboratory activities. Subjects included 42 college students enrolled in an introductory physics laboratory. Prior to each laboratory session, the order of observation was randomly determined. Several types of data were collected for each subject. First, each laboratory pair was observed for five to seven minutes during each laboratory session. During the observation period, conversations between laboratory partners were audiotaped and their corresponding activities were noted. Second, twelve subjects were randomly selected to participate in

15.08 BARDEN CONTINUED

three semi-structured interviews designed to focus on their strategy use during the preceding laboratory. Third, all subjects submitted responses to pre- and post-laboratory questions, laboratory reports, and final exams. After each four week observation period, the data were analyzed to determine the kinds of strategies exhibited. The results of the analyses were used to develop a coding sheet concerning the strategies and skills employed.

15.08

DEVELOPMENT AND ASSESSMENT OF AN INQUIRY BIOLOGY COURSE FOR NON MAJOR BIOLOGY STUDENTS

Fletcher Brown, and Dr. Jane B. Kahle, Miami University, Oxford, Ohio

This poster reviews the initial assessment and development process of an inquiry biology course for preservice teachers and biology non majors at Miami University. In this study the inquiry course is compared to a more traditional biology course. The dependent variables in this study are the level of inquiry in the classroom, content learned, process skills, science attitudes, and the classroom environment. Accompanied with the initial assessment information is documentation discussing the process of course development, the use of concept maps and the 5-E's Learning Cycle in course development, and the use of concept maps in student evaluation.

15.08

SCIENTIFIC LITERACY IN A COLLEGE PHYSICAL SCIENCE CLASS: AN INVESTIGATIVE PROJECT ASSIGNMENT.

S. L. Coleman, and A. M. Soellner, Southeast Missouri State University

An investigative project was assigned to a class of 40 physical science students during the fall of 1990. The assignment pertained to Dr. Iben Browning's prediction of a major earthquake on December 3 along the New Madrid fault. Each student in the class was asked to conduct a survey of at least 25 people in which the following questions were asked: l) is the earthquake prediction scientifically based? and 2) should schools be closed on December 3 because of this prediction? The

15.08 COLEMAN CONTINUED

answers of several respondents were to be analyzed by the students based upon the respondent's beliefs and values: a short essay was to be included describing the student's own final position. A pre-post survey was conducted in class, and results of this survey as well as comments from student papers will be reported.

15.08

INVESTIGATING THE EFFECTIVENESS OF DEMONSTRATIONS USED IN TEACHING COLLEGE PHYSICS

Kenneth W. Gattis, North Carolina State University

The purpose of the study was to examine the benefits that college physics students derive from seeing classroom demonstrations. Students saw demonstrations on two different occasions. The first used an air track to illustrate Newton's 1st and 2nd laws. The second used hoops, disks, and rotating stools to teach the concepts of moment of inertia and angular momentum. A total of 26 different students were interviewed several days after the sessions. The first demonstration was videotaped and shown to the students at the interviews. Students generally had a good recollection of what happened in the demonstrations and showed a good understanding of cause-effect relationships. When asked, students stated the law of inertia in such a way that was indicative of phenomena seen in the demonstration. Students seemed to understand the role of moment of inertia in affecting the experimental outcomes. Students did not gain an understanding of the conservation of angular momentum. It was concluded that demonstrations seem to be quite powerful in limited situations. Hypotheses were offered for the apparent effects of the demonstrations, and suggestions were made for future research.

15.08

THE USE OF A STRUCTURED DISCUSSION FOR CONCEPTUAL CHANGE IN COLLEGE LEVEL INTRODUCTORY BIOLOGY.

Carol Lena Lane, and Catherine A. Teare Ketter, University of Georgia.

The purpose of this study was to evaluate the effectiveness of structured discussions employing the hermeneutic/dialectic approach as a mechanism for conceptual change among non-science students enrolled in a college introductory non-major biology laboratory course. Student attitudes toward science courses in general and Biology specifically were surveyed in a pretest-posttest manner to determine the effect of this discussion technique on student attitude. The 156 students were randomly assigned to experimental and control groups using a Latin Square design (accounting for instructor/time/room differences). Students attended the same lecture class and lecture testing was uniform across both groups. Students' performance on three lab quiz anchor items was examined. Preliminary results indicate affective differences between gender and class rank demographic groups. Strong students reported preferences for different learning styles than average and weaker students. Analysis of variance on attitudinal change scores was performed to assess experimental/control group differences. Qualitative results from the discussion groups were transcribed and analyzed along demographic lines.

15.08

EVALUATION OF AN ALTERNATIVE CONCEPTION RESEARCH-BASED LABORATORY CURRICULUM FOR NON-MAJOR UNIVERSITY BIOLOGY STUDENTS

Gregory J. Moncada, Louisiana State University

Although there have been a considerable number of studies describing alternative conceptions, there are few that offer curricula which teach toward resolving student-held beliefs. Likewise, there are still fewer studies which evaluate the efficacy of an entire curriculum specifically created to address the most commonly encountered biological alternative conceptions. This study evaluates such a curriculum. Quantitative methods of pretest-posttest design measuring alternative conceptions were administered to all students taking the non-majors

15.08 MONCADA CONTINUED

introductory biology laboratory course (n=453). Qualitative components utilized two methods: Weekly pre-interview post-interview sessions (n=6) and weekly pre- and post-journal entries (n=10). Students interviewed are different from the students writing journal entries. Because this is a study in progress, analysis and conclusions would be premature; however, it is hypothesized that a body of biological alternative conceptions will exist among the students and that only the most closely held are most likely to be retained after targeted alternative conception curricula are used. Journal writing and interviews may also provide substantive insights for retaining such tightly held conceptions. These student generated insights will then be related to the quantitative alternative conceptions instrument as well as to their understanding of other **umbrella** concepts, such as **evolution** and **genetics**.

15.08

A NATIONAL RESEARCH AGENDA FOR GENETICS PROBLEM-SOLVING

Mike U. Smith, Mercer University

This symposium is intended to: A. Provide a forum for interactive dialogue about research issues on genetics problem solving; B. Discuss current research and the need to extend research in genetics problem-solving; C. Report the recommendations for research and classroom practice from a National Science Foundation (NSF)-sponsored national meeting of science teachers, science educators, scientists, and researchers in problem-solving and genetics problem-solving; D. Discuss the implications of this national research agenda for conducting, disseminating, and implementing research efforts by the science education community in an effort to respond to real instructional needs of students. The critical questions that served as discussion points were: I) What does research say about how teaching problem solving in the science should be done? 2) What are effective classroom instructional strategies? 3) What research questions that will inform learning and teaching need to be asked? Recommendations for research in genetics focussed on the following areas: conceptual knowledge and understanding, reasoning tasks, nature of science/genetics, desired student characteristics, and the teacher's

15.08 SMITH CONTINUED

role. Among the specific recommendations for research which emerged from conference participants was the development of a consortium for research on the learning and teaching of genetics.

19.07

COOPERATIVE LEARNING IN LARGE ENROLLMENT UNDERGRADUATE SCIENCE COURSES

Darwin W. Smith, Lynda Grynkewich, Deborah C. Leister, Lee Meadows, Allison Ross, and Lachele Foley, University of Georgia

Cooperative learning has enjoyed much support among educators in recent years, but has been slow to catch on with secondary and post-secondary-science teachers. The failure of the sciences to embrace cooperative learning is surprising because it is ideally suited to address the reasons for the failure of traditional teaching methods. We have found remarkable improvement in student comprehension and attitudes when cooperative learning was invoked in our teaching. While the large class sizes for introductory science courses at many colleges and universities (especially major research universities) may at first may appear to be an insurmountable barrier to cooperative learning, our experience is really quite encouraging. How cooperative learning is implemented in introductory chemistry courses at the University of Georgia will be described, together with the results of our ongoing assessment of these strategies.

19.07

ENHANCING UNDERGRADUATE STUDENT LEARNING OF CELL BIOLOGY: MOVING AWAY FROM THE LECTURE PODIUM

Jolie Mayer-Smith, University of British Columbia, and
Barbara Moon, Simon Fraser University

A collaborative research project investigated student learning of cell biology concepts in a first year biology majors course. It was postulated that student learning difficulties were linked to passive learning in lecture based classes. The effects of implementing generative learning strategies were studied. Student conceptions of cell biology were collected by written probes, concept mapping, and

19.07 MAYER-SMITH CONTINUED

interviews. Traditional lectures were preceded by systematic, open ended discussions in small groups. Pre-lecture discussion questions were designed based on concepts known to be difficult for undergraduate biology students. A model of student conceptions about cell functions was developed. The effectiveness of the strategies was assessed by comparing tests results of the experimental group with those of a comparison group.

19.07

STUDENTS' UNDERSTANDING OF THE NATURE OF SCIENCE: A CASE STUDY OF A SUMMER LABORATORY INTERNSHIP.

Julia M. McArthur, The University of Iowa

The investigation -- in conjunction with a quantitative study by McComas -- examines the role of a six to eight week university laboratory internship in developing secondary students' views of the nature of science. In keeping with a qualitative research framework, the researcher -- who was one of the program organizers -- acted as a participant observer making field notes to accompany a series of open-ended interviews conducted at the conclusion of the internship experience. Case records were constructed and a method of constant comparison employed in both data collection and analysis. In general, students discussed methodological elements of scientific investigation, the role of the scientist, school science experiences versus **real** science and the role of intuition and creativity in research.

20.07

MAKING COLLEGE LEVEL SCIENCE TRANSPARENT THROUGH THE USE OF CONCEPT MAPS

Peter Okebukola, Lagos State University, Nigeria,
Rosy N. Agholor, Federal Ministry of Education, Nigeria, and
Olu Jegede, University of Southern Queensland, Australia

Large classes and inadequate facilities are factors which have combined in recent years to strengthen the predominant use of a lecture mode of instruction in post-secondary schools (college level) in Nigeria.

20.07 OKEBUKOLA CONTINUED

Consequently, rote learning is prevalent. Science concepts are becoming increasingly difficult to understand and the achievement profiles are far from encouraging. This paper summarizes studies which have been conducted beginning from 1985 to improve science concept formation and attainment by university undergraduates in Nigeria through the use of concept mapping hemistic are described. A number of recommendations are made for teaching college-level science using concept maps especially in developing countries

20.07

THE ATTITUDES OF USING CONCEPT MAPS IN PHYSICS INSTRUCTION AMONG COLLEGE NON-SCIENCE STUDENTS OF NATIONAL TAIPEI TEACHERS COLLEGE, ROC AND OHIO STATE UNIVERSITY, USA

Jong-pyng, Michael Chyuan, National Taipei Teachers College, Taiwan, ROC
Arthur L. White, Ohio State University, USA

Meaningful learning affiliates new meaningful information with learner's' cognitive structure non-arbitrarily and substantively. The notion of a concept map is recognized as a research instrument, a learning method, and a teaching tool for helping students in meaningful learning. This study investigated the learning attitudes of 128 non-science students of National Taipei Teachers College (NTTC) and 106 Ohio State University (OSU) non-science students after using concept maps in learning physics concepts of linear motion. Quantitative methods were used to determine three student attitudinal variables toward (a) constructing concept maps, (b) using concept maps to study physics concepts, and (c) using concept maps to display physics concepts. Analysis of the results showed that (a) the non-science students of both NTTC and OSU have negative attitude towards constructing concept maps because it is not easy (b) NTTC students have positive attitudes about using concept map In learning physics concepts but not the students of 0SU, and (c) the students of NTTC have positive attitudes about using concept maps to display physics concepts and, (d) the students of OSU have more negative attitudes about It.

20.07

USING CONCEPT MAPPING IN A COLLEGE COURSE ON EVOLUTION: IDENTIFYING CRITICAL JUNCTURES IN LEARNING

John E. Trowbridge, and James H. Wandersee, Louisiana State University

The purpose of this study was to: (a) describe how concept mapping can be used as an integral instructional strategy for teaching a college evolution course, (b) evaluate the utility of incorporating concept mapping in a college course on evolution, (c) determine whether or not students' concept maps reveal **critical junctures** in learning, and (d) assess the impact of concept mapping on students' study practices and on students' understanding of course content. Key findings include (a) that critical junctures in learning evolution can be identified by monitoring the degree of concordance of superordinate concepts appearing on the class set of concept maps submitted after each course lecture, (b) students who made concept maps reported spending an average of 37% more study time on this college biology course than their previous biology courses, and (c) the use of **seed concepts**, **micromapping**, a standard format, and a standard concept map checklist made the strategy feasible for the instructor to implement and for the student to adopt. A map index formula was also developed for this research study.

21.07

STUDENTS' SYSTEMATIC ERRORS WHEN SOLVING KINETIC AND CHEMICAL EQUILIBRIUM PROBLEMS

Saouma B. BouJaoude, Department of Science Teaching, Syracuse University

The purpose of this study was to identify students' conceptual chemical errors and systematic mathematical errors when solving chemical equilibrium problems. To accomplish this task, the final exam responses of 189 college students enrolled in the second semester of 8 first year chemistry course for science and engineering majors were content analyzed. Results of the analysis showed that a) students seem to have an overgeneralized definition of bases which states that **all substances that contain an OH are bases**. Also, students seem to have an overgeneralized definition of acid which states that **all**

21.07 BOUJAOUDE CONTINUED

acids ionize completely to produce H+(aq); b) there is what Sheila Tobias calls a **tyranny of technique**; that is students blindly follow techniques that they have learned in class to solve problems without sufficiently analyzing these problems; c) students attempt to apply purely mathematical solutions rather than using their conceptual understanding of the problems and then solving mathematically; d) a number of students did not seem to have skills to control variables; e) students committed computational and mathematical errors that should have been mastered at a much lower educational level.

21.07

A DESCRIPTION OF UNIVERSITY STUDENTS' CONCEPTUAL CHANGES IN EVOLUTION

Sherry S. Demastes, and Ron Good, Louisiana State University

The study focused on the conceptual change of 83 university students in the area of biological evolution. Using pre- and posttest data, along with student interviews, problem sets, and classroom and laboratory discussions, instruction was found to be only moderately successful in promoting conceptual change toward a scientific conception. Additionally, a qualitative assessment of all data found three alternative conceptions to be firmly held by a large segment of the group even after instruction. These included: (a) a typological species concept, (b) evolution as a change in all individuals in a population, and (c) the variation acted on by evolution as produced by need. Evidence was given to support the piecemeal description of conceptual change. Patterns of conceptual change described include: (a) a slight movement toward a scientific conception, (b) movement away from a scientific conception, and (c) movement between various alternative conceptions. Students identified four areas of difficulty in the topic of evolution, including (a) the question of human speciation, (b) the lack of visual evidence for evolution, (c) the presence of religious restrictions, and (d) the inability to understand the mechanism of evolution.

21.07

STUDENT PERCEPTIONS OF THE EFFECTIVENESS OF COLLEGE COURSES FOR THE NONSCIENCE MAJOR

Patricia P. Franklin, The University of Virginia

The study was conducted in three phases. A: Compilation of national science goals and objectives. B: Development of the survey instrument and interview guide and subsequent study of April, 1986. C: Revalidation study of April, 1992. Basic objectives explored were the nature of science, the qualitative processes of science, the skills of science, and the issues of science, technology, and society. Discipline specific content objectives were explored in astronomy, biology, environmental sciences, and physics. The data analyzed from the surveys and interviews will be compared with national science goals and objectives to develop a model for college science teaching for the nonscience major.

21.07

COLLEGE STUDENTS' REPRESENTATIONS OF PROPORTIONAL PROBLEMS

Julia Anne Misiak, Centenary College

Task-based interviews were conducted encouraging subjects to use their existing knowledge structures for the construction of representations for six problems over two different contexts requiring proportional reasoning. The most significant goal of this study was to identify the types of knowledge structures and the reasoning processes used by these individuals. Analysis of videotapes made possible a fine-grained study of what the subjects said and what they wrote. Analysis of individual knowledge representations structures were performed in accordance with the Davis Model (1984) of Information Processing Schema. Findings indicated that the subjects established visual representations for some tasks. Sometimes individuals carried out the solutions to the tasks by verbal or written semantic reasoning processes that were extensions of their visual representations, while at other times, individuals transformed their visual representations into mathematical representations. Sometimes individuals seemed to be operating on the tasks by using whole procedures retrieved from long term memory.

22.07

PEDAGOGICAL CONTENT KNOWING: AN INTEGRATIVE MODEL FOR SCIENCE TEACHER PREPARATION

Kathryn F. Cochran, and James A. DeRuiter, University of Northern Colorado

This paper presents a brief overview of Shulman s description of pedagogical content knowledge (PCK)--teachers knowledge about teaching specific subject matter concepts. A modification of PCK based on an constructivist view of teaching and learning processes is outlined and an integrative model of pedagogical content **knowing** (PCKg) is described. In addition to teachers understandings of subject matter concepts and pedagogy the new model places increased emphasis on teachers understandings of their students and about the environmental context in which learning and teaching take place. The model is used as a basis for a list of research questions for application to teacher preparation in science.

22.07

INSTRUCTOR SELF ASSESSMENT PROGRAM (ISAP) FOR COLLEGE-LEVEL SCIENCE INSTRUCTION

J. Preston Prather, University of Virginia

The Instructor Self-Assessment Program (ISAP), a cooperative project of the University of Virginia Teaching Resource Center (TRC) and School of Education, was developed with input from faculty of five colleges and universities. Although developed for volunteer use by college-level science teachers, the ISAP has been employed by instructors in a variety on subject areas. The program is designed to assess instructional strategies and methodologies that may affect student participation, understanding, and attitudes in college and university science classrooms. It was not designed to assess subject content per se; and such evaluation, if desired, may be performed as an additional activity by specialists in the specific subject area. The program involves videotaping and reviewing a lesson, using a 30-item self-assessment instrument, either privately or with input from reviewers of their choice. This enables instructors to critique their own teaching performance from the perspective of a student or observer. A 10-item lesson assessment form, keyed to the larger

22.07 PRATHER CONTINUED

instrument, may be distributed to students to enable instructors to compare students' perceptions of the lesson with their own evaluation. Videotaping equipment and self-assessment packets are available from the TRC, and the staff is available upon request to advise and assist in program implementation or lesson assessment. Participants are not required to share information from self-assessments with the TRC; but any information voluntarily shared with the Center is handled confidentially and used for a multi-institutional research project on strategies for enhancement of college science instruction. Initial results indicated that the program is an effective, low-key vehicle for introducing new instructional concepts to instructors who may have no preparation in teaching methods or learning theory. Participants in the NARST session on research issues of college level science instruction will be encouraged to examine the ISAP program for replication in their own institutions an collaborate on further research.

24.07

REASONING STRATEGIES OF STUDENTS IN SOLVING CHEMISTRY PROBLEMS AS A FUNCTION OF DEVELOPMENTAL LEVEL, FUNCTIONAL M-CAPACITY AND DISEMBEDDING ABILITY

Mansoor Niaz, Universidad de Oriente, Venezuela

A sample of 109 freshman students were administered tests of formal reasoning, functional M-capacity, disembedding ability and chemistry problems (mole, limiting reagent, gas laws). Results obtained show that students who scored higher on cognitive variables not only have a better chance of solving problems, but also demonstrated greater under-standing and used reasoning strategies indicative of explicit problem solving procedures based on the hypothetico-deductive method, manipulation of essential information and sensitivity to misleading information. Students who score higher on cognitive variables_ tend to anticipate important aspects of the problem situation by constructing general figurative and operative models, leading to a greater understanding. Students scoring low tended to circumvent cognitively more demanding strategies and adopt others that helped them to overcome the constraints of formal reasoning, information processing and disembedding ability.

27.06

REFORMING THE SCIENCE CONTENT PREPARATION OF PROSPECTIVE ELEMENTARY SCHOOL TEACHERS

Penny Gilmer, Iain Hendron, Hedy Moscovici, Dorian Barrow,
Daniel Duffy, and Ken Tobin, The Florida State University

The calls for reform over the past decade have critiqued both the form and substance of science content that prospective elementary school teachers experience. Florida State University has initiated a reform effort focused on this specific problem: content preparation of prospective elementary teachers. Within a radical constructivist framework, curriculum development is viewed as a dialectic through which the processes of planning, translation and course implementation are connected directly to the quality of the learners' experiences. Courses in Biology, Earth and Physical Sciences are planned by Interdisciplinary Development Teams including scientists, science educators, practicing teachers, and students. The panel members will discuss the findings of a research program that has focused on the development of these courses. The foci will be on overcoming barriers to the reform and on the students' perceptions of the effectiveness and usefulness of these experiences.

27.10

AN INTELLIGENT COMPUTER ASSISTED INSTRUCTION FOR A HUMAN PHYSIOLOGY COURSE: PRINCIPLES AND ASSESSMENT

Jerome M. Yochim, University of Kansas, and
Yehudit J. Dori, Israel Institute of Technology, Haifa

An intelligent computer assisted instruction (ICAI) package, consisting of modules on the endocrine system, the digestive system, the brain, and the neuron, has been integrated into an undergraduate human physiology course. Originally, the purpose of this package was to enhance the frontal lectures with a flexible, user-friendly courseware, using text, graphics, animation, two methods of self evaluation, and an access for quick subject reviews. As the program has evolved, it currently serves as a stand-alone study unit, allowing the student to study at his/her own pace while giving timely feedback on his/her performance through quizzes and tests. Constructed as a network with an overview, knowledge is presented in a layered format, enabling

27.10 YOCHIM CONTINUED

study at several levels of depth. Students' modes of usage and learning strategies were investigated using the Card Traversal Graph tool embedded within the courseware. An assessment questionnaire is summarized, showing that the Human Physiology software was well received and appreciated.

TEACHERS AS RESEARCHERS

6.08

GETTING STARTED: AN INTERACTIVE FORUM FOR NEW RESEARCHERS

Moreen K. Travis, and Rebecca J.Pollard, Texas A&M University

The focus of this forum is to provide new researchers with an organized overview of the lines of research currently being pursued in science education. In addition, practical guidelines for the preparation and submission of manuscripts for publication will be discussed. Prominent researchers in each area will provide participants with the review of dominant themes, sources of funding, professional resources and lists of seminal readings. Participants will be encouraged to explore their own perceptions of the goals of research in their area of interest and to develop contacts with both forum members and each other.

7.09

TEACHERS AS RESEARCHERS PART 1: THE TEACHER AS RESEARCHER METAPHOR--WHAT DOES IT MEAN FOR SCIENCE EDUCATION?

Joe D. Kincheloe, Florida International University

This session will focus on the meaning of the **teacher as researcher metaphor** from a critical constructivist, postmodern perspective. Critical inquiry, the construction of an emancipating system of meaning, assumptions behind educational research and the question of what constitutes knowledge are important aspects of the metaphor that will be highlighted in this session. A question/discussion period will enable participants to engage in conversation concerning some of the issues that are raised. This session is the first in a series of four sessions that are devoted to the teacher as researcher theme.

7.09

TEACHERS AS RESEARCHERS PART 11: CRITICAL ISSUES IN ACTION RESEARCH

Karl Hook, The Florida State University,
Dee French, David Jackson, Thomas Koballa, Lee Meadows, and Deborah Tippins, University Of Georgia, and
Wolff-Michael Roth, Simon Fraser University

7.09 HOOK CONTINUED

This is the second session in a set of four which focuses on the **teacher as researcher** metaphor from a research perspective. The purpose of this session is to raise important issues surrounding: a) the involvement of teachers in research on their own practice; and b) the involvement of students in research projects of student learning, student beliefs and epistemologies and classroom organization. The session will consist of four 5-minute overviews of research designed to highlight a critical issue encountered in using the teacher as researcher metaphor. The presentations will be followed by a 20-minute small-group breakout session for the purpose of considering the critical issues raised, group reports and a general discussion. The issues addressed in the presentations will include: 1) conflict associated with the duality that encompasses the instructor/researcher roles and the student/subject roles; 2) the dilemma of getting students to speak freely and frankly in the context of an **activist research paradigm**; 3) issues concerning the trustworthiness of data generated in a context that involves a teacher and two of his students and issues of confidentiality when students are involved in the construction of data from the data sources and 4) ethical aspects of action research.

7.09

TEACHERS AS RESEARCHERS PART 111: REFLECTION IN ACTION RESEARCH

Thomas Dana, Pennsylvania State University
Anita Roychoudury, Miami University, Ohio,
Tom Russell, Queens University, Canada
Deborah Tippins, University of Georgia
Ken Tobin, The Florida State University

This is the third session in a set of four which focuses on the **teacher as researcher** metaphor. Reflection is a critical component of science education reform and is essential in the construction of new ways of making sense of experience. Reflection is also an important aspect of action research, as teachers reflect both on and in action to give meaning to experience in terms of what they know. This session will feature a debate between two science education researchers

7.09 DANA CONTINUED

expressing different perspectives on the role of reflection in action research. The initial debate will be followed by an opportunity for the two panelists to offer a rebuttal. Three other panelists will then provide brief reactions to the positions represented in the debate. Opportunities to discuss the issues raised in the debate will follow through the formation of small discussion groups. After a 20-minute period the small groups will reconvene. The other three panel members will share examples of reflection in action research, followed by group reports of the issues raised during the small group discussion sessions.

7.09

TEACHERS AS RESEARCHERS PART IV: THE TEACHERS' VOICE-TEACHERS' USE OF AUTOBIOGRAPHY AND ACTION RESEARCH TO IMPROVE PRACTICE

Jean Bartlett, Springfield Elementary, Panama City, Panama
Cynthia Brooks, Holmes County High School, Bonifay, Florida
Nancy Davis, and Amal Sidani-Tabbaa, The Florida State University
Sandra Eriksson, Niceville High School, Niceville, Florida
Barbara Eubanks, Cathy Starling, Everett Middle School, Panama City, Florida
Maggie Helly, Mosley High School, Lynn Haven, Florida, and
Kathleen Inge, Rutherford High School, Panama City, Florida

This is the fourth in a set of four which focuses on the **teacher as researcher** metaphor from a research perspective. Educational research should affect those individuals who are active participants in educating students. Who more appropriate to produce such research than the classroom teacher? Eisner (1991) discusses the concepts of educational connoisseurship and educational criticism. Through the reflection involved as teachers conduct action research they develop the knowledge of the educational connoisseur. The purpose of this session is to: 1) examine the impact of teachers' written educational autobiographies on their change process; 2) examine the impact of teachers' action research on their change process; 3) discuss issues associated with teachers' writing of educational autobiographies and action research; 4) propose a

7.09 BARTLETT CONTINUED

model of personal change based on teachers' writings. Following a brief introduction the audience will break up into smaller groups for 1/2 hour to discuss with individual teacher-researchers (elementary, middle school, high school) what they have learned from their research. These discussions will assist the audience in forming images of the types of research teachers conduct, the value of such research, and allow time for questions into their specific focus areas. The group will then reconvene to discuss the model of teacher change and research issues which arise when working with teachers as they conduct action research.

15.06

TEACHER RESEARCH IN ACTION: TRANSFORMING A MIDDLE SCHOOL SCIENCE CURRICULUM

Sheila F. Pirkle, Mary-Ellen Jacobs, and Paul D. Lee, Louisiana State University, Baton Rouge

Teachers are frequently presented with innovative strategies in inservice sessions and then encouraged to implement them in their classrooms. Usually, no follow-up support is provided, and teachers -- even if excited by the approaches presented -- often flounder. Consequently, little meaningful change occurs in their teaching practice. This study seeks to better understand how 30 sixth grade teachers transform their physics curriculum by experiencing a six week summer science institute. Using phenomenological methodology, journal texts and transcripts of group discussion are analyzed for recurring themes. Preliminary data analysis of journal entries written during the summer institute by 25 of the participants reveals nearly unanimous feelings of satisfaction. These findings suggest the power of a constructivist curriculum with its emphasis on interactive discovery learning to enhance participants' sense of their own possibilities as science teachers and, as a result, to be more committed to tapping the possibilities within each of their students.

TEACHING SCIENCE

1.02

IMPROVING SCIENCE TEACHING AND LEARNING. A HOLISTIC STUDY BASED ON CONSTRUCTIVIST PERSPECTIVES

Chorng-Jee Guo, Wu-Hsiung Chiang, Hsiao-lin Tuan, and Hei-Por Chang,
National Changua University of Education, ROC

An attempt was made in this study to explore ways to improve science instruction at the junior high school level based on constructivist perspectives. Research activities included an initial training of participating science teachers and assessment of students' alternative conceptions on selected topics. Motion and force, heat and temperature, elements and chemical compounds, and chemical reactions were selected from a junior high science textbook as study topics. Students' alternative conceptions on selected topics and constructivist views were used as the underpinnings for the development of instructional designs which were tried out, and evaluated. The development of a constructivist view of science teaching in science teachers, their teaching behaviors, their perceptions about contructivism, the effectiveness of the instructional designs and materials developed, students' learning strategies, and students' learning outcomes were studied holisticly using qualitative methods

1.02

HIGH SCHOOL PHYSICS TEACHERS' THINKING: A MULTINATIONAL STUDY

Gabriela Jonas, University of Hamburg, Germany

The purpose of this study was to compare physics teachers' thinking from three countries: The United States, Russia and Germany. Randomly selected high school physics teachers filled out a questionnaire and interviews before and after classroom observations were made. Results showed an agreement on most statements about physics experiments (teacher demonstrations and hands-on activities). Different opinions are held by teachers regarding methods of physics teaching as well as the content of physics courses. Reasons for both same and different teachers' beliefs were analyzed in the context of the countries' school systems, the roles and positions of physics teachers and physics curricula.

5.04

CONCEPT OF TEACHING EXEMPLIFIED BY TWO ELEMENTARY SCIENCE TEACHERS

Lila F. Wolfe, McGill University

This paper compares the **activities** of two outstanding teachers of elementary science. The different philosophies and strategies of each teacher, as well as the pupil outcomes, are described as brief case studies. Teaching behaviors are examined in relation to the concept of teaching as articulated by a group of philosophers of education. The point is to show how the teachers' defended intentions are consistently implemented across the teaching acts, an inherent goal of **teaching**.

5.11

USING SCIENCE PROCESS STRATEGIES TO TEACH PROBLEM SOLVING AND CONCEPTUAL CHANGE

William G. Holliday, University of Maryland at College Park

Traditional science processes, **thinking processes that characterize the scientific enterprise** popularized by the curriculum, Science, A Process Approach, combined with general learning strategies (e.g., semantic encoding, planning, restructuring) used by students and scientists might better be conceptualized, in the context of contemporary learning theory, either as science strategic knowledge or science process strategies. This broadly defined group of strategies is used to solve problems and change conceptions in the domain of science content knowledge. This theoretical paper on teaching science process strategies elaborates on this research issue by comprehensively describing three interactive data-based models (i.e., cognition, metacognition and cognitively-based motivation). This paper describes how these three models can be empirically and theoretically tied together, followed by an explanation of major findings generally pervasive across elementary and secondary school subjects—findings linked to integrated theory that forms a basis for conceptualizing science content knowledge, and science process strategy research and development in science teaching. The present research integrates, clarifies and applies a massive amount of theoretical and empirical work on teaching cognitive learning strategies to research efforts in teaching problem solving and conceptual change in science using science

5.11 HOLLIDAY CONTINUED

process strategies.

6.05

TEACHING SCIENCE WITH ACTIVITY-BASED MODELS: A RESEARCH VIDEO AND DISCUSSION

Shawn Glynn, University of Georgia,
Joseph D. Novak, Cornell University, and
Elisabeth Charron, Montana State University

In this alternative mode of presentation, a research-based video will engage the audience interactively in interpreting the research. This new, professional quality video shows exemplary science teachers--in five public schools--strategically using activity-based models and analogies to make textbook concepts **come alive** for children. The teachers creatively support the children's construction of fundamentally important concepts. After the research video is shown, cognitive (constructive) and motivational (social interactive) processes in the video will be highlighted. The audience will then analyze and interpret these processes in group discussion.

6.09

SCIENCE/TECHNOLOGY/SOCIETY: MULTIPLE RESEARCH PERSPECTIVES

Patricia E. Simmons, J. Randy McGinnis, and David Jackson,
The University of Georgia, and
Glen Aikenhead, University of Saskatchewan

This round table will focus on the role of classroom teachers, following their classroom teaching and curricular efforts, as they developed and implemented science, technology, society (STS) organizers. The principal goals of the round table are to provide a forum for interactive dialogue among science teachers and science educators about issues on research in STS and the implications of this research for models of inservice teacher education. Specifically, participants and presenters at the round table will: l) share findings on teachers' expectations, experiences, beliefs, and attitudes regarding STS; 2) engage in discussions representing diverse perspectives for the interpretation of research findings based on selected cases; 3) discuss the differences in

6.09 SIMMONS CONTINUED

teachers' characteristics and students' characteristics and relationships to the development and implementation of STS; and 4) discuss the implications for further research on STS and on models for inservice teacher education. Selected cases of eight teachers who participated in a special year long STS institute and project will serve as the focus for discussion. Composite profiles of these teachers will be shared with participants separated into small groups. During this time, each group will discuss their major conclusions and biases regarding the data in the profiles. Participants will engage in a synthesis of the conclusions and implications for research in STS and for models of inservice teacher education.

6.12

THE EFFECTS OF MENTORING UPON FIRST YEAR SECONDARY SCIENCE TEACHERS IN MISSOURI

John R. Sode, North Dakota State University

The study examined mentoring effects upon science laboratory concerns, mentoring perceptions of first year secondary science teachers, and mentoring effects upon science teacher retention, perceived teaching effectiveness, and tendency to select assistance from professional colleagues. Data were collected by use of mail survey. Four mentoring factors were identified: Professional Assistance, Science Laboratory Assistance, Mentor Availability, and Classroom Instructional Assistance. Science teachers were also found to be primarily concerned with laboratory effects upon student learning. A new statistical procedure, the Analysis Hierarchy, was developed to examine additional mentoring effects. The procedure identified independence between groups of teachers and allowed for the application of significance tests to the research data. Mentoring was found to significantly influence perceptions of teacher effectiveness between content and noncontent mentored teachers and teacher retention between mentored and nonmentored teachers. Mentoring also was found to be associated with divergence between content and noncontent mentored teachers in terms of their intentions to seek professional assistance.

6.13

USING DISCREPANT EVENTS TO TEACH COOPERATIVE GROUP PROBLEM SOLVING SKILLS TO 9TH GRADERS ENROLLED IN PRINCIPLES OF TECHNOLOGY I

Dennis Potthoff, Catherine Yeotis, and Mary Butel, Wichita State University

Tim Smith and Janet Williams, Wichita Northeast Magnet High School

Teachers as researchers. This is a project initiated by classroom teachers who formed a partnership with the university to assist their 9th grade students develop better problem solving skills. The semester-long participation of 9th grade PT students in a series of seven cooperative group problem solving discrepant events was monitored by the collaborative research team. Pre and posttest data were collected using the Torrance Test for Creative Thinking (Verbal Form A). Additional data, collected through structured observation of cooperative group interaction and group presentation, analysis of teacher feedback forms and student journals contributed to the sequential development of cooperative group problem solving skills of the 9th grade students.

7.08

NEW AND EMERGING ROLES FOR SIMULATION IN SCIENCE EDUCATION

Nancy Roberts, and George Blakeslee, Lesley College,
John Richards, and William Barowy, BBN Systems and Technologies,
and Ellen Mandinach, Educational Testing Service

Educators have recognized the power of simulations as teaching tools since the arrival of desktop computers. This intuitive recognition is stated explicitly in several documents by and directed towards educators. The National Council of Teachers of Mathematics (NCTM) guidelines make it clear that students must have a variety of opportunities to formulate and express mathematically problems based on real-world situations, to create mathematical models, and to interpret and test the results of these models against real-world data. Although national experts have called for increased attention to modeling in school mathematics and science classes, the implications are not well understood. What changes in software tools and the traditional science and mathematics curriculum may be necessary if

7.08 ROBERTS CONTINUED

students are to use models and simulations effectively at given levels? This symposium presents work from five people: Three from the same project, yet with divergent views. All five people have been involved in various aspects of modeling for several years. These projects are attempting to understand how to develop and integrate the tools of model building and simulations into pre-college education, with commitments that range from teaching students to build their own models as scientists do to giving students carefully developed simulations to use as student laboratories.

7.10

HIGH SCHOOL PHYSICS TEACHERS' THINKING; ESPECIALLY WITH REGARDS TO EXPERIMENTS IN PHYSICS COURSES.

Gabriela Jonas, University of Hamburg, Germany

The purpose of this study was to get insight into physics teachers' thinking. Data collection included a questionnaire, interviews and classroom observations. Special interest was given to teachers' thinking about the role of experiments (teacher demonstrations and hands-on activities). Results indicate that physics teachers believe in the importance of experiments and that experiments are part of an up-to-date physics class. However, they are unsure about how experiments influence students' learning and understanding of the process of physics. Other aspects of the investigation included teachers' beliefs about how content should be taught in physics classes and about methods of physics teaching.

8.03

THE INQUIRY PROFILE: AN INSTRUMENT TO OPERATIONALLY DEFINE AND ASSESS INQUIRY TEACHING/LEARNING IN THE SCIENCE CLASSROOM

Andrea Anderson and Bruce Perry, Miami University, Oxford, Ohio

A widely accepted operational definition of inquiry continues to allude science educators. The goal of the present study was to develop a set of constructs to operationally define and assess inquiry in science classrooms. The constructs were based on observable processes and were organized into an observation instrument using a five point Likert

8.03 ANDERSON CONTINUED

format. Results from piloting the instrument with 40 middle grade teachers indicated that observable inquiry processes exist and that those processes can be organized into a valid construct driven observation instrument. Analysis of post observation feedback interviews indicated consistent agreement regarding the constructs and consensus toward an operational definition of the inquiry process in middle grade science classrooms.

8.03

A QUANTITATIVE AND QUALITATIVE STUDY OF INSERVICING TEACHERS TO ENGAGE IN INQUIRY TEACHING

G. Nathan Carnes and Arta Damnjanovic, Miami University, Oxford, Ohio

According to figures released by the Ohio Division of Computer Services and Statistical Reports, there are 54,939 elementary certified teachers actively teaching in Ohio classrooms. Some of these professionals are teaching science courses at the junior high and middle school level and have little training in these subject areas. Project Discovery, a State Systemic Initiative, was established to remediate this apparent weakness. The project used the University of Washington's **Physics by Inquiry** course for the content of its summer institute. Other aspects of the project included the establishment of a regional resource center and six academic year workshops which were scheduled to facilitate the institutionalization of inquiry-teaching. The focus of this paper is to discuss the data generated by the quantitative and qualitative instruments used to assess the summer institute session. The data gathered by both types of instruments suggest that middle school science teaching behaviors may be positively affected by intensive inservice education.

8.03

THE ROLE OF OHIO'S STATEWIDE SYSTEMIC INITIATIVE, PROJECT DISCOVERY, IN FACILITATING THE USE OF INQUIRY IN THE MIDDLE SCHOOL SCIENCE CLASSROOM

Jane Butler Kahle and Ann Haley-Oliphant, Miami University, Oxford, Ohio

The purpose of this session is to elucidate the role of Ohio's Statewide Systemic Initiative, Project Discovery, in promoting the use of inquiry in the middle school science curriculum. Quantitative and qualitative analyses indicate an intensive six week Project Discovery summer institute impacted 21 middle school science teachers' attitudes and abilities to incorporate inquiry into their teaching repertoires. The level of inquiry in the classrooms of these teachers was determined by using an inquiry profile as well as teacher developed portfolios. The inquiry profile was created by developing a set of constructs based on observable processes and organized into an observation instrument using a five point Likert format. The portfolios were used to investigate their role in developing individual and collegial reflection on the use of inquiry in science teaching.

8.03

THE USE OF TEACHER PORTFOLIOS FOR INDIVIDUAL AND COLLABORATIVE REFLECTION: A CASE STUDY FROM A MIDDLE SCHOOL SCIENCE INSERVICE PROGRAM

Ann Haley-Oliphant, and Andrea Anderson, Miami University

The purposes of this study are as follows: (a) to investigate the role of portfolios as a tool for the development of individual and collegial reflection on the use of inquiry in science teaching and (b) to investigate the role of portfolio of development and collegial relationships in the systemic reform of middle school science teaching. Twenty-one teachers attending a six week inservice course participated in this study. The results indicate that the level of reflection became quantitatively and qualitatively more intensive throughout the year as the teachers explored the use of inquiry in their classroom. Second, the collegial discussions occurring during the six academic year workshops influenced the development of the teachers' portfolios both in content and reflection.

8.08

IMPLEMENTING AN EXPANDED IN-DEPTH SCIENCE STRATEGY IN ELEMENTARY SCHOOLS: 5-YEAR LONGITUDINAL FINDINGS, POLICY IMPLICATIONS, AND RESEARCH ISSUES

Nancy R. Romance, and Valerie Bristor, Florida Atlantic University, and Michael R. Vitale, East Carolina University

This paper summarizes and discusses the policy and research implications of cumulative findings obtained over a 5 year period (51 teachers, 1200 students) from the implementation of an in-depth expanded science strategy with a variety of student populations in grades 2-5 . The strategy replaces the time allocated for traditional reading/language arts instruction with a daily 2 hour time-block dedicated solely to in-depth science concept instruction (e.g., concept-focused teaching, hands-on activities, extensive utilization of science process skills, enhanced reading of trade science materials). The results presented confirm a consistent overall pattern for the strategy's effectiveness in improving the science knowledge and reading achievement of participating students, along with the positiveness of their affective feelings (e.g., attitude, self-confidence) toward science and reading. Additionally, the paper overviews supporting research findings clarifying the strategy's effectiveness, including benefits for students at different ages and ability levels, cumulative effects of multi-year participation, teachers' perceptions of benefits and support needs, and the development of a large-scale strategy-implementation model. In context of these findings, the paper then discusses policy implications and associated research issues raised by the strategy's underlying theoretical foundations that emphasize the integration of the conceptual structure of science knowledge with a constructivist view of learning.

8.08

PUPPETRY AND COMICS IN PRIMARY SCIENCE EDUCATION: AN INNOVATIVE APPROACH TO THE LEARNING OF SCIENCE CONCEPTS.

Marissa Rollnick, University of the Witwatersrand, Basil Jones, and Michael Kahn, Handspring Educational Trust, South Africa.

8.08 ROLLNICK CONTINUED

This paper describes a distance learning science education project which uses three media to address conceptual change at the primary level. The media are a broadcast television series using puppets, a videocassette and a printed comic book/workbook. The project aims to develop a series of television programs and popular literature which utilize research findings on alternate conceptions in science. The vehicle for the project is an adventure story based on the lives of an urban group of South African children. An initial pilot episode and comic/workbook has been produced and is being evaluated. The presentation will discuss the results of the evaluation and further explore the use of the media in the learning of science concepts. The evaluation will address questions of how to adapt the program to various cultures, how to use the program in education for development, how best to achieve optimum delivery of the materials and the use of the conceptual change strategies.

8.08

TEACHING SCIENTIFIC THINKING SKILLS THROUGH EXPLORATION OF MICROWORLDS

Anat Zohar, Teachers College, Columbia University

This study compared the reasoning strategies of students who conducted a self-directed investigation of microworlds, with those of students who investigated the same problems in small groups, with teacher's guidance. Findings from a qualitative analysis of students' cognitive processes are described. The subjects were 25 Community College students in a lower income neighborhood in a large city. The findings show that moving from individuals without any guidance to peer collaboration accompanied by a didactic intervention, enhances the progress in students' strategic reasoning skills. The qualitative case study analysis indicated that both the peer collaboration and the didactic intervention contributed to this enhancement. The didactic model that consists of: a. creating a cognitive conflict from a scientific type example; b. simple intuitive example; c. moving back to the scientific-type example; d. generalization of strategic rule and, e.

8.08 ZOHAR CONTINUED

applying this rule to numerous scientific sort examples- was shown to be useful. A prolonged period of practice was shown to be necessary to stabilize a skill. Although both experimental groups were engaged in the same tasks, it seems that the two different environments induced some qualitative differences in cognitive processes. The implications of these findings for classroom implementations are discussed.

10.02

HOW TEACHER BELIEFS AND KNOWLEDGE INFORM PRACTICE

Joy E. Bielenberg, University of Colorado

The purpose of this study was to describe and interpret how the knowledge and beliefs of a teacher inform and shape the teaching process. An overall description of the knowledge and beliefs of the teacher is revealed through interviews and observation of classroom instruction. This description gives the reader a sense of the teacher's perceptions of her role as a teacher and the influences which have shaped those perceptions. Classroom activities are analyzed and the constraints and supports of the instructional setting are identified. Finally, parallels between the teacher's view of the nature of science and her descriptions of teaching and learning are examined.

10.02

THE RELATIONSHIP BETWEEN TEACHER INTENTIONS AND THEIR CLASSROOM USE OF SUPERSCIENCE

David P. Butts and Thomas R. Koballa Jr., University of Georgia

Using the conceptual model of reasoned action, one would expect that what teachers do with instructional materials would be influenced by their internal beliefs and their external constraints. This was a two-year study of elementary teachers using a supplemental science instructional resource, SUPERSCIENCE. It was found that teachers' internal beliefs about what will benefit their students are linked to the external constraints of their students' interests and the expected curriculum. Even if teachers believed that the content of the resource would be helpful, they were not likely to use it if they believed it did not fit the expected curriculum.

10.02

CHANGE IN TEACHING SCIENCE: A CASE STUDY OF AN ELEMENTARY TEACHER

Mark Guy and Jayne Seawright, The University of Georgia

The purpose of this study was to explore the meaning of a change experience from the perspective of an elementary teacher. Using qualitative case study methodology, a descriptive and interpretive narrative of the process of teacher change as a lived-experience was the focus of the study. Student performance and characteristics, the teacher-student relationship, curriculum content, and local school culture provided an overall context within which to analyze the data. Findings were organized around themes of teacher perceived constraints and aids during implementation of desired changes. Implications for further research and staff development are offered.

12.08

ELEMENTARY TEACHERS WHO TEACH SCIENCE: AN ALTERNATIVE ACCOUNT FOR WHY JOHN AND JANE DON'T KNOW SCIENCE BASED ON LORTIE'S ETHOS OF THE AMERICAN SCHOOLTEACHER

Jean Ann Foley, University of Tulsa

By analyzing elementary teachers who teach science, this study proposed to learn how these teachers think about science and relate to science. The teachers were analyzed using three sources of information: Classroom, science workshop, and biography. Research for science programs to improve science education in elementary schools has focused on the lack of science background of elementary teachers who teach science, the lack of confidence in teachers who teach science, the lack of administrative support, and the lack of science lab supplies. The findings from this study suggest that the possession or lack of these elements may have little or no bearing on successful science teaching. Rather, it is the present-oriented, non causal perspectives of the elementary teachers described by Lortie (1975) that seem to perpetuate the cycle of using activities as a substitute for science and deferring science content to later grades.

12.08

TEACHER KNOWLEDGE AND REPRESENTATION OF CONTENT IN INSTRUCTION PROMOTING THE DEVELOPMENT OF SCIENTIFIC KNOWLEDGE OF HEAT ENERGY AND TEMPERATURE

Shirley Magnusson, and Joseph Krajcik, The University of Michigan

This paper discusses teacher knowledge and practice with respect to topic-specific instructional strategies for teaching about heat energy and temperature (HE&T). The topic-specific strategy knowledge (TSSK) component of teacher pedagogical content knowledge (Shulman and Grossman, 1988) was examined. A conceptual framework was developed for distinguishing more and less effective content representations (McDiarmid, Ball, & Anderson 1989) in laboratory activities about HE&T. Randomly-selected experienced teachers (n=6) who participated in a teacher enhancement project using microcomputer-based laboratories to promote the development of scientific knowledge were interviewed before and after conducting multi-week instructional units about HE&T. Results indicated that most of the teachers did not exhibit substantial knowledge of the activities which most effectively represented the content: Those emphasizing the distinction between HE&T. Furthermore, there was no relationship between knowledge of activities emphasizing the distinction between HE&T, and their instructional use of activities emphasizing the distinction between HE&T. These results indicate that teacher TSSK may not be differentiated with respect to the distinction between HE&T, an important feature of powerful representations in this topic area.

13.04

INTEGRATING THE ORGANIC AND THE MECHANISTIC TRADITIONS OF ECOLOGY IN THE MIDDLE SCHOOL CLASSROOM; A CASE STUDY

Doris B. Ash, University of California, Berkeley

We describe research illustrating how curriculum design was accomplished by integrating principled ideas from within the historical and philosophical foundations of ecology. First, we outline the mechanist and organicist frameworks, two traditions that co-define ecology. Next, we suggest several important principles that accompany proposed integration, for example, the notion of mutual

13.04 ASH CONTINUED

interdependence of ecosystem components (Worster, 1977; Odum, 1963). Last, we describe research that focused specifically on children's collaborative research of the causes for endangered species status in a wide variety of student-selected animals during three iterations of an environmental science learning cycle in an inner city school. The majority of the students were academically at risk with more than 80% bilingual or bidialectical. Research encompasses three stages and uses an innovative design philosophy (Brown et al, in press). Analyses combine both qualitative and quantitative assessment formats in order to more completely describe the complex world of the classroom. Qualitative methodologies include clinical interviews (Ash, 1991), that act as in-depth pre and post intervention assessments of children's reasoning about complex ideas and discourse analysis.

13.06

THE EFFECTS OF ABILITY-PAIRED EXTERNAL VERBALIZATION BY FIFTH GRADERS ON BALANCE CONCEPT ATTAINMENT

Glenda Carter, North Carolina State University, and
M. Gail Jones, University of North Carolina, Chapel-Hill.

In this study, we looked at the effects of ability-paired student interactions as subjects worked on laboratory activities relating to balance. Achievement gains were assessed (n=83) by analysis of pre/posttest differences on the Lever Concept Test. Audio recordings and field notes (n=30) were analyzed for the following laboratory behaviors: Number of words spoken, tinkering, block moving, turns speaking, incidence of helping and distracting behavior. Results revealed that low ability students scored high when paired with high ability students. Low ability students spoke more words, exhibited less distracting behavior and moved blocks on the lever more when they were paired with high ability students. High ability students also spoke more words, took more turns speaking, and exhibited more helping behaviors when they were paired with low ability students rather than with other high ability students. However, there were no achievement differences for high ability students regardless of the ability level of their partner. These findings imply that heterogeneous grouping of

13.06 CARTER CONTINUED

students in science is beneficial to the low ability partner and not detrimental to the partner of high ability.

13.06

CLASSROOM TASK AND TALK STRUCTURES IN TWO APPROACHES TO ELEMENTARY SCHOOL SCIENCE INSTRUCTION

Charles Fisher, and Alice Horton, University of Northern Colorado, and Robert Marzano, Mid-continental Regional Educational Laboratory

This study compared the kinds and amounts of thinking that fifth-grade students engaged in during science instruction in **content-centered** classrooms with instruction that integrated **thinking processes** and **content**. Case studies of science teaching and learning were conducted in four fifth-grade classes followed by a cross-case analysis. Approximately 16 hours of lessons were video taped and transcribed. Task and talk structures were identified in these data and interpreted in terms of current theories of classroom learning. Cognitive tasks in the **integrated** classes compared to the **content-focused** classes were faster paced; students spent more time in **interpretative** activities and less time in **practice** activities; the cognitive complexity of the activities was generally higher; and students had more influence on the design of the products they produced. Based on specific patterns in talk structures, the pairs of classes were differentiated with relative consistency on: (a) purposes of science instruction, (b) views on the nature of scientific knowledge, (c) views on science teaching and learning, and (d) content coverage of science topics.

13.06

NAVIGATING IN A SEA OF IDEAS: TEACHER AND STUDENTS NEGOTIATE A COURSE TOWARD MUTUAL RELEVANCE

Lawrence B. Flick, Washington State University

The purpose of this study was to analyze the science instruction of a 4th grade teacher whose teacher education program of 20 years ago led to an endorsement in reading and provided no specific coursework in science or science education. In recent years, she has developed skills and knowledge in science and math education through inservice and

13.06 FLICK CONTINUED

coursework. The study focused on a 31-day unit on the topic of space planned entirely by the teacher. The study uses linguistic theory, Vygotskian perspective of concept formation, and Britton's theory of language functions to analyze students' oral and written language. I argue that verbal explorations in the classroom expanded the cognitive environment in unexpected ways some beneficial and some resulting in misleading or erroneous ideas. However, the interpretations of children as evidenced by the ideas expressed during instruction and in the interviews revealed significant convergence on important concepts as a result of a wide-ranging search for information relevant to student thinking and experience. I discuss implications for elementary science instruction, inservice education for elementary teachers, and statewide systemic initiatives seeking to affect change across a broad range of elementary classrooms.

15.05

MISCONCEPTIONS AND BELIEFS OF GENERAL CHEMISTRY I HISPANIC STUDENTS ABOUT CHEMISTRY, MASS, VOLUME, AND DENSITY

Mary Ann Davison, InterAmerican University of Puerto Rico

This study was conducted with two groups of Hispanic general chemistry I students in Puerto Rico. Students were asked written open ended questions about chemistry, why study chemistry, mass, volume, and density in order to identify misconceptions, and beliefs. Their responses influenced the next class meeting in that concrete examples help differentiate between mass, volume, density, macro and submicro properties were incorporated. The responses also led to formulating four proportional reasoning problems that were administered to one of the groups 13 weeks into the semester. The answers were reread recently and categorized. The data were used to categorize their approach to solving the problems. The results showed that these students have numerous misconceptions about chemistry, mass, volume, and density. Some attitudinal beliefs about the discipline were also discovered.

15.06

STUDENT EVALUATION OF TEACHER PERFORMANCE: A REVIEW OF LITERATURE AND INSTRUMENTS FOR SCIENCE EDUCATORS

Sandra J. Finley, and Frank E. Crawley, Science Education Center, University of Texas at Austin

A review of literature (1977 to 1991) was undertaken to: (1) determine the status of research pertaining to the utilization of student evaluations of teaching; (2) evaluate the specific studies that pertain to use of evaluations for the improvement of science teaching; and (3) examine the instruments available for use by science educators. Eighty percent of the studies were found to be in higher education, with a large number of these studies investigating and generally confirming the reliability and validity of student evaluations. Only one to two percent of the studies concerned science classrooms, and there was a lack of research addressing the utility of feedback from evaluations for teaching improvement. Few instruments were found that are specifically designed for use in science classrooms. A table summarizes the results.

15.06

BEING A SCIENCE TEACHER: RELATIONS BETWEEN THOUGHTS AND ACTIONS

Peter W. Hewson, and Lyman Lyons, University of Wisconsin-Madison

This study investigated the relationship between the thoughts and the actions of experienced high school science teachers (4 in each of biology, chemistry, and physics). Teachers' thoughts were obtained from an analysis of Conceptions of Teaching Science interviews. Their actions were obtained from an analysis of extensive classroom observations of three topics and three post-topic interviews per teacher. These two analyses were performed independently before comparing and contrasting them. The comparative analysis showed that there was variability in the congruence of thoughts and actions across teachers. Some teachers were well aware and in control of their practice; their thoughts and actions were highly congruent. Other teachers had some obvious discrepancies between their vision of ideal practice and the reality of their classrooms. These outcomes suggest

15.06 HEWSON CONTINUED

the value to both pre-service and in-service science teachers of reflecting in coherent ways on all aspects of their practice.

15.06

CONSTRUCTING PORTRAITS OF TEACHERS' THOUGHTS AND ACTIONS: CAPTURING MULTIPLE PERSPECTIVES

Robert E. Hollon, and Patricia K. Freitag, University of Wisconsin-Madison

Multiple observer perspectives are incorporated into the development of a case study of high school chemistry teaching. The teacher's beliefs about science, learning, and instruction are described and related to patterns of practice and conceptions of teaching science. Student tasks emphasized learning facts and procedures, but limited opportunities for developing meaningful understanding of important concepts. The teacher relied on a set of self-reinforcing beliefs which were inconsistent with constructivist perspectives. Multiple interpretive frameworks are illustrated using annotated video technology. Issues of case development, teacher reflection, and implications for teacher education are discussed.

15.06

MISMATCH: PERSPECTIVES OF TEACHERS AND LEARNERS IN SECONDARY SCHOOL LABORATORY ACTIVITIES

Jane O. Larson, Yokota High School

This study attempts to further illuminate discrepancies in viewpoints of teachers and learners which have been revealed in previous research (Tasker, 1981; Osborne, 1985) by analysis of anecdotal descriptions of episodes from participants' experiences in high school laboratory activities. The critical incident technique is used to elicit and analyze narratives concerning a successful and unsuccessful laboratory experience in which the respondents acted as teachers or learners. Approximately 40 teachers and 150 students completed open-ended questionnaires. The episodes are being classified with Spradley's domain analysis in order to tease out and categorize pertinent behaviors and conditions which are common to, or unique to, the

15.06 LARSON CONTINUED

groups. Critical elements for laboratory work will be constructed for each group, and differences and similarities noted. Information is expected to reveal teachers' and learners' requirements for goals, desired learning environments, preferred roles and ideas on the nature of learning.

15.06

WHAT THEY SAY AND WHAT THEY DO: COMPARING CHEMISTRY TEACHERS' BELIEFS ABOUT THE NATURE OF SCIENCE TO THEIR PRACTICE

Lyman L. Lyons, University of Wisconsin-Madison

This study, part of a larger National Science Foundation (NSF) study, examined the beliefs of four chemistry teachers about the nature of science and compared these beliefs to their classroom actions. The teachers were observed and videotaped while teaching three topics, a total of about thirty hours per teacher. Their teaching was compared with statements they made in an interview conducted prior to observations. All four teachers emphasized science as a body of knowledge in their teaching, which contrasted with their interview statements. The teachers differed regarding their explicit statements about science and the implicit messages students received from classroom and laboratory practice. One of the teachers emphasized the historical development of theories of the atom and occasionally gave his views on certain aspects of science. The other three teachers made few explicit statements about science. The teachers also differed on the frequency and style of their laboratory activities. Follow-up interviews with the teachers are planned to discuss their views regarding the degree of correspondence between their stated beliefs about the nature of science and their classroom actions.

15.06

WHOSE LAB IS THIS? THE ROLE OF THE LABORATORY IN PHYSICS' TEACHERS' PRACTICE

Timothy P. Olsen, and Peter W. Hewson, University of Wisconsin-Madison

This study investigated the role that the laboratory played in the classrooms of four experienced physics teachers. These teachers were interviewed using the Conceptions of Teaching Science Interview to capture their general thoughts about teaching science. They were also observed teaching topics on Newton's Second Law, Mechanical Energy, and (for two of them) Electric Circuits; and interviewed at the conclusion of each topic about details of their teaching of the topic. The analysis of observation and interview data showed that there were significant differences in the way teachers used labs that were illuminated by adopting two complementary perspectives; one describing the roles the teachers play in structuring the contexts of lab, the other clarifying how the lab context constrains students' roles and thus their learning.

15.06

A STUDY OF THE EFFECT OF CHROMATOGRAPHY ON SECONDARY STUDENTS' UNDERSTANDING OF MIXTURES AND SOLUTIONS AT THE MOLECULAR LEVEL

Michael S. Wittrig and Mary B. Nakhleh, Purdue University

Students participated in a one week unit on mixtures and solutions using a variety of chromatographic techniques. The unit included a paper chromatography exercise as well a high performance liquid chromatography (HPLC) demonstration. We investigated students' molecular-level understanding of chromatography, mixtures, and solutions on a pre/post-interview basis. Students exhibited different levels of understanding, but in all cases, the necessity of understanding how the instrumental techniques relied on molecular-level properties was evident.

19.03

THE SCIENCE CLASSROOM OBSERVATION RUBRIC (SCOR): A CONSTRUCTIVST APPROACH

Judith A. Burry, and Dennis Sunal, The University of Alabama, and
Kathleen Pittman, Livingston University

The Science Classroom Observation Rubric (SCOR) was designed as a constructivist observation rubric to be used with science classroom observations for grades four through either. It was constructed as part of the research efforts of the Expert Science Teaching Project from the OERIR&D Center called Center for Research on Educational Accountability and Teacher Evaluation (CREATE). The SCOR was built using classroom observation scripts from 46 expert science teachers in seven states. The SCOR has a reliability coefficient of .91 for the overall total and all of the categories subscale are above .80. A principal component factor analysis with an orthoginal solution accounts for a clean four factor structure with all of the squared factor loadings above .55 and 73% of the variance accounted for by 18 constructivist behaviors.

19.03

RESOLVING CONFLICTS: TEACHERS' IMPLEMENTATION OF CONSTRUCTIVISTIC SCIENCE CURRICULA IN OUTCOMES-BASED SCHOOLS

Stacey E. Marlow, The University of Hawaii, and
Michael P. Marlow, Jackson County Intermediate School District

The study used a naturalistic design to examine the implementation of constructivistic science curricula developed by teachers in two Michigan school districts. Data were collected from curriculum documents, teachers' reflective journals, field notes from observations, and interviews with teachers. Three questions guided the research: 1) How are the principles of constructivism evident in student and teacher behavior during science instruction; 2) What factors constrain or support curriculum implementation; and 3) What are the conflicts between outcomes-based assessment testing and the principles of constructivism, and how do teachers reconcile them? The findings indicated that elementary level teachers implemented constructivistic instructional strategies more readily than secondary

19.03 MARLOW CONTINUED

teachers. Elementary teachers collaborated more in the implementation process than did secondary teachers. Teachers who participated in the curriculum development process were more committed to implementation. Secondary teachers and elementary teachers in grades preceding the level at which state assessment tests were administered more often adhered to traditional, rather than constructivistic, instructional strategies.

19.03

A HIERARCHICAL LINEAR MODEL OF HIGH SCHOOL SCIENCE ACHIEVEMENT

Deidra J. Young, Curtin University of Technology,
Arthur J. Reynolds, Yale University, and
Herbert J. Walberg, University of Illinois at Chicago

A theory of educational productivity (Walberg, 1984) holds that three groups of nine factors a) aptitude consisting of 1) ability or prior achievement, 2) motivation, and 3) age or developmental level; b) instructional 3) time and 4) quality; and c) the psychological environments of the 6) classroom, 7) home, 8) peer group, and 9) mass media are the major and consistent determinants of educational outcomes. This study used the hierarchical linear model (HLM) and the Longitudinal Study of American Youth (LSAY) in order to investigate Walberg's educational productivity model. The significance of the relationship between student performance in science achievement was confirmed in this HLM analysis, with most of the variables tested found to contribute towards explaining student differences in science achievement.

19.08

CONCEPTIONS OF TEACHING SCIENCE HELD BY EXPERIENCED HIGH SCHOOL SCIENCE TEACHERS

Holly Walter Kerby, Peter Hewson, University of Wisconsin-Madison, and Perry Cook, University of North Dakota

The conceptions of teaching science held by experienced high school science teachers (4 in each of biology, chemistry, and physics) were obtained from an analysis of Conceptions of Teaching Science interviews. The analysis showed that: (1) teachers' conceptions could be represented by a few coherent themes that linked central ideas of science, learning, and instruction together; (2) there could be tensions between different themes; (3) teachers often talk about very different aspects of the central ideas; and (4) even when teachers talk about the same thing, they might interpret its usefulness in very different ways.

19.08

TWO WORLDS OF SCIENCE: AN EXAMINATION OF AN ENRICHED AND GENERAL SCIENCE CLASS

Keith McElroy and Edward Smith, Michigan State University

This is a case study of an enriched and a general science class taught by the same teacher. The study describes the differential treatment of the two classes as a consequence of ability grouping the students. It does this by characterizing the nature of the academic work done by the students as well as the development of the classroom climate in the two classes. The finding shows that in the enriched class a supportive and nurturing climate developed, while in the general class, an increasingly antagonistic climate developed along with the development of a group of students that became alienated from the teacher and the subject matter. The social structure created by the students interacted with the school's placement policy in ways that perpetuated the placement practice and its consequences. Social bonding theory provided a theoretical perspective that yielded insight into why these climates developed and points towards possible ways in which positive climates can be fostered in a larger percentage of science classrooms.

19.08

A DESCRIPTION OF THE THEORY-PRACTICE INTERFACES OF THESE SECONDARY SCIENCE TEACHERS: AN EXPLORATORY STUDY

Debra Tomanek, North Dakota State University

The exploratory study was conducted to determine the ways in which educational theories and practical knowledge were involved in three science teachers' thoughts and actions as curricula were implemented in their classes. Specifically, the study focused on the thoughts and subsequent actions that ultimately altered the intended curricula. Douglas Roberts' concept of theory/practice interfaces provided the conceptual framework for the study. Analysis of the results suggest that educational theories influenced the teachers' decisions about the intended curriculum. However, as the curriculum was implemented during lessons, the teachers' considerations of educational theories often contradicted their personal knowledge of the immediate events at hand. When this occurred, the teachers' practical knowledge dominated the theory/practice interface. This line of research has implications for teacher education. As teachers are educated in theory, they may need simultaneous opportunities to consider how practicing teachers use theories.

19.11

DEVELOPMENTAL RESEARCH AS A WAY TO AN EMPIRICALLY BASED DIDACTICAL STRUCTURE OF PHYSICS

P.L. Lijnse, University of Utrecht, The Netherlands

Research on pupils' ideas has drawn attention to the problems of learning physics. Proposed solutions are in general inspired by a constructivist cognitive science perspective and are formulated in terms of new teaching strategies. However, such solutions usually leave the conceptual structure of the curriculum unaltered. In our view, **developmental research** is needed in which small scale curriculum development is cyclically coupled to indepth classroom research of the teaching learning process. This should result both in practically worked out examples of new teaching strategies and in new conceptual curriculum structures. An empirically based related description of both teaching and learning activities and processes gives what we call a

19.11 LIJNSE CONTINUED

didactical structure for the teaching and learning of a particular topic. This constitutes a longer term research programme of which examples, for the topics of radioactivity and energy will be briefly discussed.

20.08

TEACHING EVOLUTION USING A CONCEPTUAL CHANGE STRATEGY AND HISTORICAL ARGUMENTS

Murray Jensen and Fred Finley, University of Minnesota

A teaching unit on evolution incorporating the theory of conceptual change and the history of evolutionary thought was delivered to an entry level college biology class. The teaching unit provided students with opportunities to solve evolutionary problems from both Lamarckian and Darwinian perspectives, and then critiqued their answers through the use of historical materials. Evaluation was made through the use of an evolution test, given both before and after the intervention. Students' pretest and posttests were compared to measure changes in their comprehension of Darwin's theory of evolution by natural selection. Statistical analysis showed student performance on posttests to be significantly better than on the pretests. A second data analysis was used to analyze the relationships between students' subjective answers, and their reasons for those answers, on both pre and posttests. Data from that analysis indicated that the teaching intervention was effective at changing functional misconceptions with more valid views of evolution. Results showed students ability to produce the best possible answers, correct objective answers accompanied with a correct justification for the same answer, improved after the teaching unit.

20.08

EVALUATING TEACHER PERCEPTIONS OF PROJECT STAR: AN INTERDISCIPLINARY TEAM-BUILDING PROGRAM

Cathleen C. Loving, Texas A&M University

Project STAR (Science Thematically Across the ClassRoom) is a four-

20.08 LOVING CONTINUED

week, summer program (followed by six follow-up meetings) for teams of middle school teachers from the Fresno, California and the surrounding Central Valley region. Each team consists of a science and a mathematics teacher and one or more of the following teachers: Social studies, language arts, fine arts or special education. Emphasis in the program is on cooperative team-building and on creation of interdisciplinary units--later to be implemented at the school--that address important science, technology, and societal issues. Initial session topics cover the 1990 California Science Framework, with its emphasis on deeper conceptual understanding of the **big ideas** in science: Natural integration of the sciences and other disciplines; contructivist approaches to learning; ongoing authentic assessments; and acknowledgment of the themes tying the big ideas together. Evaluation of teacher perceptions of the summer phase included both quantitative and qualitative methods: pre-and posttest items, periodic group and individual interviews conducted by a trained participant observer, and a **final personal evaluation** with open-ended questions addressing specific goals. Results revealed particular strengths in the program's ability to build confidence in interdisciplinary team work and in level of familiarity and comfort with the Framework by teachers of all disciplines.

20.08

DEVELOPING AND IMPLEMENTING AN INTEGRATED SCIENCE COURSE

Gail Richmond and Joanne Striley, Michigan State University

A conceptual change-based, interdisciplinary science curriculum was developed by science teachers, science educators and scientists in order to facilitate tenth-grade students' abilities to critically analyze and integrate scientific concepts across disciplines as they are traditionally taught. The hallmark of the course was a thematic approach to the study of science using water as the focus for investigating principles and concepts. The course revolved around the use of three major case studies, all of which are dependent upon water for their expression. Using student-generated experiments, journal writing, group work, and alternative means of assessing student knowledge, teams of teachers and researchers were able to

20.08 RICHMOND CONTINUED

develop unique ways to assess students' concepts and misconceptions and adjust ongoing teaching to accommodate these. It also has facilitated students' abilities to apply concepts which they have learned in new contexts. Additionally, it has revealed very fruitful ways in which teachers and researchers can collaborate inside and outside the classroom in order to further understand the nature of student learning.

21.08

CONCEPTUAL MODELS AND BRIDGING STRATEGIES: A CASE STUDY

P. Elizabeth Pate, David A. Hayes, and C. Stephen White,
The University of Georgia

In this investigation we examined an instructional approach that provides both the conceptual models for comprehending subject matter and bridging strategies for developing knowledge within the science domain. Conceptual models are sets of statements or spatial representations that explain and connect the science material to be learned. Bridging strategies (i.e., concept maps, analogies) connect new subject matter to the established pattern of knowledge. This investigation took a case study approach. One participant in the study was an eighth grade science teacher in a middle school located in rural Georgia. The study entailed classroom observations, conferences, and collaboration with the teacher to develop materials and plan instructional units. A conceptual model of the Earth's waters was developed to present the general concept for understanding subsequent presentations. The teacher and researchers collaborated on a unit of fresh water that incorporated the conceptual model and bridging strategies. The teacher then independently developed a unit on salt water that included instructional strategies providing bridges between material previously presented and newly introduced material. The teacher began the study wary of this approach but soon became comfortable developing units incorporating conceptual model and bridging strategies.

21.08

SECONDARY SCIENCE CLASSROOM PEDAGOGY: A SYMBOLIC INTERACTION STUDY

Meta Van Sickle, University and College of Charleston

The question asked during this study was, **What classroom pedagogy occurs in classrooms with science teachers who are perceived to be caring?** The research was completed using the symbolic interaction tradition, so that science educators could describe science teachers who are perceived to be caring for the first time. Two of the schools used in the study had populations of 50 percent or more at-risk students. These students were generally absent from all recitations during the day except the science classrooms studied. The pedagogy in these classrooms was consistently interactive. Student-student and teacher-student dialogue was regularly exercised in the classrooms studied. The pedagogy for the dialogues was observations, questioning, decision making, cooperative grouping, and experiential learning. The teachers and students in these classrooms were consistently engrossed with the lesson in progress. Students who did not typically attend classes generally came to these classes. All students in the class participated in the lesson, and all students appeared to have a consistently positive attitude toward science. The interactive nature of the classroom pedagogy was described by all the data sources as important to the ethic of care in these science classrooms.

21.08

HANDS-ON TEACHER EDUCATION ACTIVITIES INVOLVING SCHOOL AGE PUPILS: EFFECTS ON TEACHER PLANNING AND SUBSEQUENT INSTRUCTION

Russell H. Yeany and John R. Wiggins, The University of Georgia

This study tested means to help teachers incorporate instructional activities that meet the needs and learning styles of individual students. Intervention with teachers involved participation in a workshop that included school aged children, sort of a **hands on** approach to teacher education. Content of the instruction concentrated on astronomy and space exploration. Children (age 9-12) were involved in instruction in the mornings while teachers debriefed and planned for instruction

21.08 YEANY CONTINUED

during the afternoon. As teachers developed and taught lessons, they were encouraged and provided with feedback on incorporation of the theoretical dimensions which guided the workshops. Results indicate that the activities had a positive effect on teachers as evidenced by: (l) knowledge about teaching as defined by the model presented in the workshop; (2) the potential impact of that model; (3) ability to plan; and, (4) their ability to teach using the model. Data indicate almost all the teachers considered multiple intelligences and dimensions of learning a number of times in planning. Good patterns of usage were planned for and significant frequencies were incorporated. Observations of teachers indicated that they planned for dimensions of learning and use of multiple intelligences were also evidenced in teaching. A significant amount of planned and actual teaching time was dedicated to types of teaching required for students to maximize learning based on different learning styles.

21.14

TEACHERS' INITIAL PERCEPTIONS OF A CONSTRUCTIVIST MODEL OF INSTRUCTION

James E. Marshall, California State University, Fresno

While many teachers accept the tenets of constructivist learning theory, they appear resistant to changing their own instruction. This resistance may stem from the lack of concrete instructional models which have direct applicability in the classroom. In this study, 66 K-12 teachers of science were exposed,in a three-week summer institute, to a model for constructivist instruction. The model consists of four stages: Activation, Exploration, Reflection, and Action. During the institute, constructivist teaching was modeled and teachers were provided opportunities to use the model by developing, piloting and critiquing constructivist lessons. Initial perceptions of teachers concerning constructivist teaching and the model for constructivist instruction were gathered. Overall, results indicate high rates of acceptance and willingness to change. Plans have been made to gather long-term perception data as the teachers implement the model during the 92-93 and 93-94 academic years.

22.08

AN INVESTIGATION OF THE DEPENDENCE BETWEEN CHARACTERISTICS OF AND PURPOSES SERVED BY LABORATORIES USED BY SECONDARY SCIENCE TEACHERS IN GEORGIA

Trina Boggus Boteler, Gwinnett Technical Institute, and
Edward C. Lucy, Georgia State University

School science laboratories will be affected by a paradigm shift toward student-centered learning that is presently occurring in science education. As with any shift, curriculum change and implementation will be determined by the teacher. Researchers today not only need to find out what teachers are doing in lab, but also why they are doing what they are doing. In order to conceptualize the factors that relate to the types of labs teachers use, a model was developed. This study focusses on one part of that model and identifies any dependence between the characteristics of types of labs used and the purposes teachers believe are served by labs. A survey was developed and sent to 334 secondary science teachers in order to identify characteristics and purposes believed served by labs as well as those purposes considered by the respondents to be most important. Responses were analyzed using descriptive statistics and loglinear analysis. Some mutual dependence was identified for three characteristics and associated purposes. Responses as to whether or not certain purposes are served by the labs teachers utilize resulted in low percentages for inquiry-related purposes. However, teachers did identify student-centered purposes as the most important.

22.08

THE DEVELOPMENT AND EVALUATION OF AN EXPLICIT COGNITIVE STRATEGY FOR TEACHING PREDICTION PROBLEM SOLVING IN BIOLOGY

Derrick R. Lavoie, Montana State University, Bozeman

The purpose of this study was to develop, evaluate, and modify an explicit prediction teaching strategy (EXPRTS) for teaching successful cognitive behaviors of prediction problem solving in biology. EXPRTS included components of cognitive strategy such as think-aloud teacher modeling, verbal rehearsal, metacognition, coaching, and practice with

22.08 LAVOIE CONTINUED

corrective feedback. Employing a randomized pre-test post-test control group design, twelve in-service elementary methods students were assigned to a control group (without EXPRTS) and twelve students to a treatment group (with EXPRTS). Paired t-tests indicated the experimental group achieved significant gains in predictive success. Comparative systematic analysis of students' cognitive behaviors identified through verbal-protocol analysis revealed substantial increases in the application of declarative knowledge compared to the control group. Successful cognitive behaviors were identified relative to teacher-student interactions, student-peer interactions, and individual student problem solving. Questions arose concerning transfer, group problem solving methods, and facilitating changes from explicit to implicit information processing.

24.02

PROBING THE VIEWS OF KEY RESEARCHERS ON THE STATUS OF THE ALTERNATIVE CONCEPTIONS MOVEMENT: AN INTERNATIONAL STUDY

James H. Wandersee, Louisiana State University, and
Joel J. Mintzes, University of North Carolina at Wilmington

Thirty leading or promising alternative conceptions researchers worldwide were selected, via purposive stratified sampling, to participate in a study designed to probe their views on the prospects of what Millar (1989) has called the Alternative Conceptions Movement (ACM). A sequence of three focused, open-ended questions was designed to identify the bases of research decision-making and to assess the progress of the ACM. A content analysis of the responses of the 70% who took part in the study yielded 28 principles considered salient by two or more of the researchers queried. The findings have the potential to improve future research and can serve as a lens through which to view the 2,400 + extant studies catalogued by Pfundt and Duit (personal communication).

24.05

URBAN SCIENCE TEACHING: UNIQUE PROBLEMS, RESEARCH AND IMPLICATIONS FOR TEACHING SCIENCE AND TEACHER PREPARATION

Craig A. Berg, The University of Wisconsin-Milwaukee, and
Cheryl Mason, San Diego State University

Due to the changing demographics and socio-economic status of our nation, more of our science students come from the urban environment which produces different and sometimes very challenging problems when trying to teach science. Lack of family support systems, very diverse cultural and ethnic backgrounds results in many difficulties including language barriers, and sporadic attendance/high absenteeism rates make teaching in the urban school difficult or at least very different from other situations. How science teachers tend to deal with these constraints often results in a **Pedagogy of Poverty** (Habermann, 1991) and has very little benefit to the urban science student. The symposia participants and audience members are going to: 1) define the unique characteristics, difficulties and constraints of the urban science classroom compared to suburban or rural situations; 2) examine potential solutions including descriptive research of urban science teachers who have developed exemplary programs in spite of these unique problems; and 3) discuss the implications for the preparation of urban science teachers.

24.08

EVOLUTIONARY PRECURSORS: HOW PRE-HIGH SCHOOL TEXTS PREPARE STUDENTS TO STUDY EVOLUTION IN SECONDARY CLASSROOMS

Kodi Jeffery, Louisiana State University, and
Linda Roach, Northwestern State University

Elementary and middle school science texts were analyzed for the presence of **evolutionary precursors**, which are defined as topics which prepare students to study evolution in later years. Elementary texts were evaluated for evolutionary precursors in both life science and earth science. Middle school life science and earth science texts were also analyzed. Fourteen concepts considered important for student understanding of evolution were gleaned from the misconception literature and used to review the life science texts. Concepts used to analyze other texts were chosen by scanning all texts used in the

24.08 JEFFERY CONTINUED

analysis for any topics that might qualify as evolutionary precursors. We recommend using evolutionary precursors when considering textbooks for adoption and for supplementing texts currently in use.

24.08

A CONTENT ANALYSIS OF CEPUP - AN STS MIDDLE SCHOOL CURRICULUM.

Obed Norman and Thomas Elliot, University of Georgia

The content of a widely used National Science Foundation (NSF)-funded middle school science, technology and society (STS) curriculum, CEPUP, was analyzed according to a system developed by Chiapetta, et al.(1990). The analysis determines the weight accorded to each of the following categories: 1. Science as a body of knowledge; 2. Science as a way of investigating; 3. Science as way of thinking; 4. The science, technology, and society interface. A five percent random sample of pages from each module was analyzed. The analysis was performed independently by two raters and the measure of agreement between the two raters determined.A second component of the analysis was to scrutinize the table of contents, as well as the actual pages of the CEPUP modules in order to determine to what extent the science topics recommended by the National Science Teachers Association (NSTA) are covered in the modules. The results show that the science-technology-society interface is emphasized heavily while the other categories receive relatively little attention. The second analysis shows that very few of the science content topics recommended by the SSC project of the NSTA are included in the modules.

24.08

ANALOGIES IN CHEMISTRY TEXTBOOKS

Rodney B. Thiele and David F. Treagust, Curtin University of Technology, Perth, Australia

This study of analogies in chemistry textbooks was conducted in two parts. An initial examination of ten chemistry textbooks used by high school students determines the extent and nature of the analogies contained therein. Specifically, the study

24.08 THIELE CONTINUED

investigated 93 analogies and compared the frequency of: a) analogy use for different chemistry topics, b) pictorial analogies, and c) instructional strategies included with the analogy that aim to assist the student to use analogies. It also describes the extent of analogical mapping and presence of further analogical explanation identified within each analogy. Secondly, interviews were conducted with the authors of eight of the textbooks. This part of the study reports the views held by the authors concerning analogy use with respect to: a) reasons for inclusion or exclusion of analogies, b) appeal for different analogy types, c) understandings of how students use analogies, and d) changes they may make to a later edition of their own textbook if they were provided with a larger repertoire of analogies. Conclusions from the results of both parts are provided with implications for teaching, textbook writing, and research.

27.07

ENVIRONMENTAL EDUCATION: AN INTERDISCIPLINARY APPROACH TO SCIENCE EDUCATION

Margaret Bogan, Jacksonville State University

This is a report on the findings of an exploratory path analysis of the **awareness to action** model for environmental education and suggest teaching strategies which lead to the expression of environmental literacy by secondary science students. Environmental literacy is defined as (a) knowing the scientific principles of ecology, (b) being aware of the potential magnitude of human impact on the biosphere, (c) showing concern for all living species, (d) valuing responsible environmental behaviors (through the process of values clarification), and (e) participating in political action strategies that lead to planetary well-being. The environmentally literate individual: (a) commands cognitive and affective knowledge about his or her biological and physical surroundings; (b) possesses political know how; and (c) displays a willingness to engage in responsible environmental behaviors. Social processes permit the transference of scientifically generated information to the voting public.

28.06

MISEDUCATION THROUGH INDUSTRIAL RHETORIC: A TRAGIC OUTCOME OF UNCED

Many ... problems have arisen from a development model that is environmentally destructive (Agenda 21, 1992)

Joan Russow, University of Victoria, Canada, and
David White, Educator and Research Ecologist

In documents emerging from the Earth Summit in Rio, there was significant recognition of the urgency of the global situation, and of the need to act upon strong principles that were adopted through consensus by the global community. Rather than these principles forming a new basis for science and environmental education, these principles have been redefined to,justify industry's increased intrusion into education. Industry is not only continuing and increasing its practice of distributing unsolicited materials to schools and offering allurements to teachers,but also becoming legitimized as a participant in the designing of the philosophical underpinnings of **Sustainability** education. This trend will be examined in the light of additional mandates given to scientists, science researchers and science educators in the UNCED documents to address the potential irreversibility of the current global situation.

28.06

SCIENTIST AND TEACHER PARTNERSHIPS IN ELEMENTARY SCHOOLS

Elizabeth A. Wier, University of Delaware

The Science Alliance in Delaware is a coalition of industry, business, and education working together to enhance science teaching at the precollege level. One of the Alliance's major programs is the development of elementary teacher and scientist partnerships, with the goal of combining the expertise of the scientists and teachers to enrich science teaching in the teachers' classrooms. This paper describes the development of the partnership program over several years based on evaluation of several partnership efforts. Those efforts, including a 1989 pilot project, provided direction for establishing long-term partnerships in fourteen schools. For example, evaluation findings indicated that: schools where several teachers and a

28.06 WIER CONTINUED

supportive principal were interested in partnerships should be targeted; coordinators are needed to provide on-going assistance in keeping partnerships going and evaluating the results; and training for the scientists partners is needed. This paper provides examples of partnership activities and evaluation procedures. In addition, this paper includes a report of preliminary work in assessing whether children who were involved in partnerships increase their awareness that women as well as men can become scientists.

28.09

THE SITUATED NATURE OF MIDDLE SCHOOL SCIENCE TEACHING: AN INTERPRETIVE STUDY OF A NINTH GRADE CLASS

Armando Contreras, Universidad de Los Andes, Trujillo, Venezuela

Drawing on Vygotskian theories of cognition and knowledge of ethnography of communication and focussing on specific details of subject matter organization in school science and math, this study asserts that teachers and students, through their daily interactions, construct sociocultural contexts that limit students' language mastery and communicative competence as well as their development of higher order thinking skills. The assertion is based on ethnographic data (140 classroom observations, videotapes and interviews) collected during a whole school year with three science and one math teacher and a class of 32 ninth grade students in a middle school located in the Venezuelan Andes. The findings have implications for teacher, program and school development as well for students understanding of genuine scientific concepts.

USE OF TECHNOLOGY

1.02

A COMPUTER AIDED INSTRUCTION MODULE ON POLYMERS

Yehudit J. Dori and Niza Barnea, Israel Institute of Technology, Haifa

Polymers is a subject studied as an elective unit by senior high school students in Israel who major in chemistry. Motivated by a lack of adequate means to model dynamic processes and 3D structures of polymers, the hazard and cost of experiments with polymers, and the need for different complexity levels, we have developed a CAI module on polymers. The module consists of three topics: Organic chemistry, polymerization, and structure and characteristics. Three **information organizers**: Concept map, data base, and index, enable easy navigation and access to information. Each topic ends with a set of problems, for which immediate responses are provided. Use of graphics and animation enables vivid display of molecular structure and polymerization processes. The module has been assessed by teachers using two tools: A questionnaire and the Card Traversal Graph, and was found to respond to needs that originally motivated us to develop the software.

1.08

THE USE OF MICROCOMPUTER GRAPHIC AND ALPHANUMERIC MODES WITH STUDENTS' PROCESS SKILLS AND CONCEPTUAL UNDERSTANDING

Sandra Eidson, West Hall County High School, and
Patricia E. Simmons, The University of Georgia

The relationship of microcomputer graphics and alphanumeric modes of data presentation to students' process skills and conceptual understanding of selected genetics concepts was the focus of this study. The theoretical framework for this research was Paivio's dual coding theory that learners can encode and recall information better if they employ a visual method and a verbal method for storage of information. Sixty-four ninth grade high school biology students used a genetics computer program, CATLAB, to solve problems by practicing process skills applications and testing basic genetic principles. Students' process skills were assessed by items taken from the TIPS II and the MIPT. Conceptual understanding of genetics was also assessed. The use

1.08 EIDSON CONTINUED

of either the graphics or the alphanumeric modes of data presentation in CATLAB appeared to significantly increase students' scores on posttest conceptual assessments and on various process skill subtests. The use of the graphics mode of data presentation in CATLAB appeared to significantly increase students' scores on the process skill subtests, identifying variables, operationally defining variables, and designing investigations. The use of the alphanumeric mode of data presentation revealed a significant difference on the process skill identifying variables.

1.08

A COMPARATIVE STUDY OF PRELABORATORY PREPARATION USING COMPUTER SIMULATIONS IN THE CHEMISTRY CLASSROOM.

John S. Schaller, Florida State University

The purpose of this investigation was to substitute an alternative prelaboratory instructional strategy for the lecture format and examine the relative effectiveness of the treatment within a given sample population. The research hypothesis under investigation is that a prelaboratory preparation consisting of a computer simulation improves student levels of achievement as compared to the traditional prelaboratory lecture format. Two treatment groups were randomly selected from a sample population of secondary Chemistry I students matched on three ability levels. One group received a traditional prelaboratory lecture introduction to the Boyle's Law experiment, while the other group received the interactive computer simulation experimental treatment. A pretest and posttest were administered to both groups. An attitude survey was conducted at the end of this experiment. The data collected from the pretest and posttests were subjected to a two-tailed 3X2 ANOVA. The findings reflected results similar to those reported in previous studies of computer assisted instruction. Most students perform as well with computer instruction as they do with the traditional lecture and demonstration mode of instruction. Additionally, 60% of the students indicated they preferred to use the computer simulations prior to entering the laboratory, and 82% reported they wanted more computer exercises in their chemistry curriculum.

5.10

TECHNOLOGY AS A PART OF HUMAN CULTURE IN A STS PRE-SERVICE COURSE FOR BIOLOGY STUDENT-TEACHERS. A CASE STUDY.

Huppert Jehuda,University of Haifa, and
Lazarowitz Reuven, I.T.T. Technion, Haifa,Israel

Technology is an integrated discipline which is a component of the fundamental education of all students. In order to enhance pupils' awareness about the process of technology between scientific knowledge and practical application, and to achieve a better understanding of technology as a part of human culture, a different approach toward STS should be introduced into the science programs at High Schools. A STS pre-service course was developed and offered to student teachers (biology). The main goal was to help student teachers understand the role of technology in human culture, with an emphasis on biotechnology. The course description and the outcomes of the case study will be presented at the conference.

6.02

CONCEPTUAL CHANGE, CONTENT ACQUISITION AND INSTRUCTIONAL VARIABLES RELATED TO NEW TECHNOLOGIES IN THE SCIENCE CLASSROOM

Gerald Abegg, David Chuckran, Boston University
Patricia Freitag, University of Wisconsin-Madison
Isabel Chagas, Universidade de Lisboa

Studies by Sherwood et. al.(1987) and Bransford et. al. (1988 used the videodisc to create new contexts for learning. In a review of research on the use of IVD, Leonard (1992) documented the myriad of benefits of the IVD systems in the schools. The Apple Classroom of tomorrow (Fisher 1989) reported changes in the classroom environment including the empowerment students experience when given control over their learning through the use of interactive technologies. These papers provide a basis for action research related to a standard instructional model. This paper set presents the results of three studies designed to examine the role and impact of the Computer-Interactive Laservideodisc as a component of the teaching learning process in science classrooms. The research specifically tests an instructional model in which the IVD plays a role as an instructional

6.02 ABEGG CONTINUED

resource, source of information or intelligent tutor. The three studies include; a case study examination of the initial use of the IVD by middle school science teachers, the intensive use of student generated multimedia in high school environmental science classes; and, the examination of conceptual change while middle school students engaged in authoring topical lessons. The instructional model will be presented as an overview for the research and will be re-examined in light of the findings.

6.02

TEACHERS AS INNOVATORS: A CASE STUDY OF THE IMPLEMENTATION OF INTERACTIVE VIDEODISC IN MIDDLE SCHOOL SCIENCE

Isabel Chagas, Universidade de Lisboa, and
Gerald Abegg, Boston University

This study was designed to determine the effectiveness of the implementation of the use of the Interactive Laservideodisc (IVD) in the classes of two middle school science teachers. The teachers volunteered to receive special training by a third teacher who is considered an expert in the field and to engage in the introduction of the IVD in their regular classes. Using ethnographic methods, classes were observed over a period of four months to determine the relationships between the methods and practices of the teachers and the impact of the innovation as it was introduced. Data was also collected on the teacher and student background and experience with the use of computers. Each teacher chose a different approach when introducing the IVD in the classroom. One teacher chose to have the students become the **resident experts** while the other chose to serve in that role himself. The students devoted additional out of class time to the problems presented by the IVD lessons and made extensive use of library and media center resources. Within the classrooms the dialog changed from teacher-centered interactions to much more student-student interaction and some student-teacher initiated interactions.

6.02

EFFECTS OF STUDENT PRODUCED INTERACTIVE MULTIMEDIA MODULES ON STUDENT LEARNING

David Chuckran, and Gerald Abegg, Boston University

This study, designed to measure the effectiveness and feasibility of student produced interactive multimedia, was conducted with seventy high school students in an environmental science course. Students used HyperCard™ and a Macintosh computer interfaced to a videodisc player linked to a TV monitor. Three classes were involved in the study. Each class was assigned a programming strategy, webbed or linear, and a conceptual model of a biome "pyramid" or "T." The students were tested for content acquisition, self-efficacy/outcome expectancy and attitudinal responses. The students worked in cooperative groups of three or four. The groups selected a specific biome of the world for their multimedia project. The students exhibited a positive response to the assignment and a ratio greater than 3:1 suggested the project be included in the course again next year. Student self-efficacy/outcome expectancy using the Microcomputer Beliefs Inventory pre and post revealed: Self-efficacy constant with females and increased with males, outcome expectancy constant with females and decreased with males. The mean scores on a criterion referenced context test pre and post revealed a significant increase after development of multimedia modules. Students with little computer experience and no HyperCard™ experience produced interactive multimedia in a high school setting. Students learned ecology content and had a positive attitude toward the process.

6.02

LEARNING WITH LASERDISCS: MIDDLE SCHOOL STUDENTS EXPLORE WEATHER TOPICS THROUGH AUTHORING PROJECTS

Patricia K. Freitag, University of Wisconsin-Madison, and
Gerald Abegg, Boston University

This study investigated middle school students' learning as they used an intelligent laservideodisc to create interactive multimedia projects about **weather**. The relationships between cognitive learning variables, students' developmental readiness, cognitive structure, and the instructional materials students used were

6.02 FREITAG CONTINUED

investigated. GALT, Locus of Control, and Concept Maps assessed students' readiness and cognitive structures. Fourteen small groups (3-4 students) of eighth grade science students worked for ten instructional periods over five weeks to research, interpret, and create original links between textual and visual information in HyperCard. Audiotapes and computer records from each workstation are used to describe the group authoring process and student learning. Results indicate that direct student use of laservideodiscs in the middle school classroom extends the students' possible learning experiences, motivates students to stay on task, and can be effectively used by students for meaningful learning. Despite significant differences between groups in GALT scores, prior to computer experience, and self rating, these variables did not appear to influence the project outcomes. This **hands on** approach to introducing new content, new technical skills, and metacognitive strategies promotes cooperative learning and motivation for science learning.

6.04

TECHNOLOGICAL SUPPORT FOR LEARNING SCIENCE THROUGH PROGRAMMING

Mark Guzdial, The University of Michigan

Science educators have long hoped that computer programming might offer a new avenue through which science might be explored. Current efforts are successful but at the high cost of Ideracy in the computatbnal medium. This cost can be reduced by changing the task of programming with technological support in order to make it more accessible. Emile is a design support environment for high schools students who are expbrTng physics by constructing multimedia programs for other students, such as microworTds, demonstratbns, and simulations. Student use of Emile has been studied in two workshops on kinematics, in which students create their first microworld in the first three hours of use and are building programs of their own design in the first week. Emile makes programming more accessible by eliminating syntax errors, providing a component library on which to base designs, using multiple representations, prompting for articulation and reflection, and using adaptable scaffolding to support students of

6.04 GUZDIAL CONTINUED

various abilities. Through clinical interviews and analysis of log files (recording every student operation in Emile), a picture is emerging of how students used Emile and how they learned physics during that use.

6.04

CONCEPT MAPPING AND EDUCATIONAL SOFTWARE PRODUCTION IN SCIENCE

Jaime Sánchez, University of Antofagasta, Antofagasta, Chile.

The purpose of this study was to study the use of a metalearning technique such as concept map as a tool for software development in science education. As a result of the software production we labelled GAMETO and more recently, The Second GAMETO, a methodology of using concept maps has been developed. The methodology of using this modern metalearning technique in diverse stages of educational software production and the distinctive role of concept maps to support the pedagogical components of educational software are discussed. A set of software components to assist science education is analyzed as a way of illustrating the application of modern constructivist ideas in the process of educational software production. Finally, results indicate that concept maps are powerful metalearning tools that improve the production of high quality educational software. Specifically, they help science learners to construct and reconstruct learning more meaningfully.

7.04

IMPLICATIONS OF GROUP USE OF COMPUTERS IN UNIVERSITY BIOLOGY LABORATORIES: RESULTS OF A QUALITATIVE STUDY OF PRESERVICE ELEMENTARY TEACHERS

B. James Hood, Middle Tennessee State University

This report presents the results of a qualitative study of 88 preservice elementary teachers, which were observed while using hypermedia CAI in a university biology laboratory. Sixteen groups (2 to 4 members per group) used the tutorials and their actions were recorded by videotaping and remote digitilization of the computer keystrokes and mouse actions. This study was performed as a non-participant

7.04 HOOD CONTINUED

observation and data were analyzed by constant-comparison techniques, which resulted in the determination of two classes of verbal and non-verbal interactions: Directional and critical communications. Directional communications caused different computer information to be viewed and critical communications expressed the individual's feelings or attitudes about implementation of and the content in the tutorials. Zones of interaction were also determined and it was noted that there was a spatial relationship that affected the frequency of communications. The results of this research were used to develop suggestions that would lead to more effective group implementation of CAI.

12.06

STUDENT LEARNING AND TELECOMMUNICATIONS NETWORKS

Nancy B. Songer, University of Colorado, Boulder,
Marcia Linn, University of California, Berkeley,
Roy Pea, Northwestern University, and
Beverly Hunter, National Science Foundation

Telecommunications networks are a resource that has begun to be utilized in many arenas, yet has a potential for K-12 learning that is unexplored and unstudied. The three presentations and discussion of this symposium share a common foci: Coupling the implementation of network technology with detailed research on student learning, collaboration models, learning communities, and software design for a K-12 audience. The individual presentations will contain the following emphases: In the **Networking and Scaffolded Knowledge Integration** project, students utilize network technology and the pedagogical approach of scaffolded knowledge integration to help students develop cohesive scientific ideas. In the **Kids as Global Scientists** project, Internet connectivity within Middle School Internet Laboratories allow classrooms of students to collect and interpret an extensive variety of National Weather Service weather data and images in the development of integrated conceptual understandings. The **Project Enhanced Science Learning (PESL)** project offers learning partners opportunities to engage in authentic scientific inquiry through apprenticeship. Their vision uses new

12.06 SONGER CONTINUED

technologies to extend the collaborative **reach** of PESL to include diverse expertise among remote learners, teachers, and scientists. The next decade brings widespread, networked multi-media interpersonal computing. These projects will provide a blueprint to inform the effective use of interpersonal collaborative media for science education.

15.02

BIOMAP: AN INTERACTIVE HYPERMEDIA ENVIRONMENT TO PROMOTE CONCEPTUAL UNDERSTANDING IN BIOLOGY

Sharolyn Belzer, Michael Jaffe, and Robert Kozma, The University of Michigan

Contemporary learning theory views learning as an active, constructive process whereby the learner strategically manages the available cognitive resources to create new knowledge by extracting information from the environment and integrating it with prior knowledge. This proposal describes a scaffolded, interactive hypermedia environment designed to present students with information using several different **perspectives** and to foster conceptual understanding, within a social context. Students will either begin their BioMap instruction by entering a simulation (game component) or a resource base first. We will use this system to study how the form of initial instruction (simulation vs. resource base) interacts with prior knowledge, influences motivation and use of metacognitive and learning strategies within BioMap, and relates to conceptual understanding. We will specifically focus on whether or not use of the BioMap system, by undergraduate non-science majors, reduces common misconceptions related to evolution and natural selection. Data collected on students include pre- and post-tests on content, questionnaires on motivation and BioMap evaluation, log files tracking student paths through the system, and responses to questions. Talk-alouds assess how students think and use features in BioMap. Follow-up interviews elucidate student beliefs by challenging them to defend their explanations when presented with alternative conceptions.

15.02

ELECTRONIC DISTRIBUTION OF AEROSPACE EDUCATION INSTRUCTIONAL MATERIALS

Loretta Cardinale and Mary Sandy, Virginia Space Grant Consortium

Resources that support aerospace-related curriculum are available from N.A.S.A., N.O.A.A., and other contributors. Electronic networking allows communication between teachers and resource contributors. Accordingly, an electronic network, Virginia's PEN, was provided to all school districts that include an aerospace user group. This project facilitates the distribution of resources and interaction among providers and users in three phases. In the first phase, the Virginia Space Grant Consortium project coordinator identified existing programs and electronic networks, users and student populations, contributors and services, and specific hardware and software needs. During the second phase, the program investigated network usage and instructional materials downloading by a pilot study group. The third phase of the project allows for software and hardware revisions, materials development to enhance use, and general recommendations regarding the quality, quantity, and types of lessons and laboratory activities that would support PEN usage. By focusing on an interdisciplinary approach within an aerospace theme, the project will foster an integration of mathematics and science.

15.02

THE EFFECTS OF EARTHSTORM, A TECHNOLOGY-BASED NSF SPONSORED INSTITUTE FOR MIDDLE SCHOOL SCIENCE TEACHERS

Ann M.L. Cavallo and Brian L. Gerber, The University of Oklahoma

This study was conducted in the first year of an National Science Foundation sponsored project (EARTHSTORM) that emphasized the use of a remote sensing computerized system for teaching weather-related topics in middle school science. The purpose of this research was to explore relationships between EARTHSTORM teachers and their students in three major areas: Cognitive, affective and technical computer skills. The teachers involved in the EARTHSTORM summer institute (N=16) were pre-and post-tested on their understanding of weather, computer skills and attitudes toward meteorology and science. Measures were also obtained on the teachers' general tendency

15.02 CAVALLO CONTINUED

to barn meaningfully a by rae (meaningful learning aientation) and on their achievement maivation (performance a learning based). During the academic year students were given the same pre and post-evaluations as their teachers. This study provided information on the influence of the EARTHSTORM institute on improving teachers' and students' computer skills and weather- related attitudes and understanding. This study also identified relationships between teachs-s' and their students' computer skills, attitudes and understandings of meteorology as well as relationships between meaningful learning aientation and achievement motivation.

15.02

TEACHER AND STUDENT LEARNING IN A PROJECT- I CENTERED, TECHNOLOGY-RICH ENVIRONMENT

Elizabeth Doster, David F. Jackson, Deborah J. Tippins, and
Thomas R. Koballa, University of Georgia

This poster session presents a formative evaluation of an ongoing collaborative project in which science education faculty and upper elementary school teachers investigate the potential of a project-based, technology-rich, environmentally-oriented approach to science education in an urban school serving a racially diverse population. Inspired by Eliot Wigginton's Foxfire methodology (originally developed in the context of language arts teaching), the project represents an attempt to adapt it to a science and technology subject matter emphasis. Inservice education activities were designed to familiarize teachers with (I) constructionism, a synthesis of constructivist learning theory and project-based teaching and curriculum development strategies, and (2) microcomputer and telecommunications technologies and their application to the development and documentation of student projects. Participating teachers and their students then completed two units from a model nationwide curriculum of this type, KidsNet. We present evidence of the degree to which teachers' attitudes and practices changed during the course of the school year as a result of these experiences, and the effect such changes had on their students.

15.02

CONCEPTUAL CHANGE IN A MICROCOMPUTER BASED PHYSICS LABORATORY

Gregory J. Kelly, Cornell University.

In this poster session I will report on an ongoing study of conceptual change in a microcomputer-based physics laboratory. The research purpose is two-fold: 1) to identify salient features influencing the learning of physics, and 2) to establish a baseline for a more complete study analyzing conceptual change in relation to student affect and epistemology. Microcomputer-based laboratories (MBL) show great pedagogical promise both for transforming students' naive notions to richer understandings and for portraying science in a more authentic manner. The poster session format will allow for demonstrations of the technologies in use. The display will include a microcomputer interfaced to technologies to demonstrate pedagogical methods developed at the Technical Education Research Centers (TERC), Tufts University, and Dickinson College as well as those developed at Cornell University specifically for the introductory physics course under study.

15.02

A MULTIMEDIA INSTRUCTIONAL ENVIRONMENT IN SCIENCE: DESIGN ISSUES AND AN EXPERIMENTAL STUDY OF USE IN A CLASSROOM

Robert D. Sherwood, Anthony Petrosino, Susan R. Goldman, Steve Garrison, Daniel Hickey, John D. Bransford, and James W. Pellegrino, Learning Technology Center, Vanderbilt University

Prototype video based science materials were developed using the design principles of **Anchored Instruction**. These materials involved students trying to solve problems related to a tanker of unknown liquid overturning and threatening a town's water supply. In an experimental study, where various groups of secondary school students used the materials in different ways, several outcomes were observed. Students in the theorized strongest condition, active participation in problem solving along with video to develop a contextual framework, were able to answer content questions better than students in conditions not designed to be optimum (passive viewing). Also, positive

15.02 SHERWOOD CONTINUED

changes in student attitudes were found on some assessment items with students showing more interest in learning more about various scientists. Some transfer items related to the use of topographic maps also showed positive results.

15.03

COLLABORATIVE RESEARCH; USING NEW TECHNOLOGIES IN A MIDDLE SCHOOL SETTING

Pierce Farragher, University of Victoria, Victoria, B.C.

This paper presents an overview of computer related action research conducted as part of a collaborative relationship between a university, a middle school and a government sponsored technology center. Five teachers conducted classroom research on the following topics: Using multimedia (interactive laser disc) to teach science; cooperative learning strategies using computers in science classes; social interaction and computer use; using HyperCard™ as a research tool in social studies. The findings of four of the action research projects are discussed along with the teachers' suggestions for further enhancement of their practice.

15.03

THE EFFECTS OF COMPUTER ANIMATION ON THE ALGORITHMIC AND CONCEPTUAL EQUILIBRIUM PROBLEM SOLVING OF COLLEGE CHEMISTRY STUDENTS

Vickie M. Williamson and Michael R. Abraham, University of Oklahoma

This study explores the effectiveness of computer animation depicting chemical equilibrium at the particulate level on students' understanding. Previous studies involved the effects of animation on conceptual understanding. In this study understanding at both the conceptual and algorithmic levels are investigated after treatment with animations. Animations were used in recitation using two methods. In the first method, the students were asked to count particles, and emphasis was given to the reversibility and dynamics of the animation. In the second, the students were additionally asked to calculate the equilibrium

15.03 WILLIAMSON CONTINUED

constant. These treatments were compared to a control group. Students were given figurative (conceptual) problems and analogous mathematical (algorithmic) problems. Success on these conceptual and/or algorithmic problems was also investigated in relationship to reasoning ability as measured by the Test of Logical Thinking. Students' explanations for their responses were also analyzed.

15.10

DISSEMINATION BY STATE SCIENCE SUPERVISORS OF A CD-ROM DISC FOR INNOVATION IN CURRICULUM PLANNING

Edward Britton, The National Center for Improving Science Education

This study explored why 35 state science supervisors disseminated Science Helper, the first application of CD-ROM technology in science education. Four research questions were addressed: (a) What dissemination activities did state science supervisors conduct? (b) How did workplace environment and role definition influence their actions? (c) What demographic and professional characteristics of the supervisors affected their actions? (d) What characteristics of Science Helper influenced the supervisors to disseminate it? Primary data were interviews; other sources were conversations, electronic communications, and correspondence. Software was used to code and sort these qualitative data. State science supervisors reported 268 dissemination activities consisting of 12 types of activities and involving 14 types of clients. Supervisors valued Science Helper's lessons, praised its search system for finding relevant lessons, and found Science Helper's features to be compatible with their beliefs about curriculum. State science supervisors can be energetic change agents when they perceive the innovation to have advantages, and dissemination of the innovation is consistent with their role as curriculum consultants.

15.10

TECHNOLOGY USAGE AND THE NEEDS OF SCIENCE EDUCATORS

Jon E. Pedersen and Jacqueline O'Dell, The University of Arkansas

The study was conducted on current members of Association for the Education of Teachers in Science (AETS). The survey was sent to all members and asked them to indicate their technology usage as well as their needs for training in technology as they prepare science teachers. The results of the survey indicate that science educators have little formal training in the use of computers and technology. Data also suggests that few science educators are currently in the process of updating their knowledge of computers and/or technology. Also, the technology most frequently used by science educators are: l) overhead transparencies, 2) films and 3) videotapes. Science teachers rank their knowledge low in the areas of how a computer functions, ways in which computers can be used and how to use a computer for spreadsheet, database and time management applications. It is clear more needs to be done in the preparation of higher education faculty to use technology in methods courses. More importantly, it is important to find ways to keep existing faculty current.

19.06

USING TECHNOLOGY TO MEASURE CHANGE IN STUDENTS' SCIENCE LEARNING

Carl Berger and Charles Dershimer, University of Michigan

The purpose of this study was to find if students were more consistent and purposeful as they became more familiar and successful with a microcomputer supported chemistry instructional program. A multimedia interactive software package was used as the learning environment. The package contained screens of information in text and picture form, animation, simulation, video segments, focus questions, inquiry questions and an organizing concept map. Students could navigate by clicking on icons that initiated the next event or state of learning. Data were gathered automatically in log files and over 1,870 state changes were analyzed for seven students having two experiences with the program. Results indicated that students varied widely in using the materials and with experience students moved from browsing and unconnected study to question driven consistent action.

19.06 BERGER CONTINUED

Students became more similar to each other as they worked indicating a shared underlying conceptual structure. Such multimodal learning tools can provide opportunities for students with wide differences in learning style yet encourage a common or shared instructional goal. Instructors using such tools can be more confident that students are converging on instructional goals and multimedia interactive software programs for students may assist in reaching science teaching objectives.

19.06

STUDENT CHOICES WHILE USING AN INTELLIGENT TUTORIAL SYSTEM IN GENERAL CHEMISTRY

Mark S. Cracolice, University of Oklahoma
Anthony T. Jacob, Catherine H. Middlecamp and Arthur A. Eggert, University of Wisconsin-Madison

CHEMPROF is a computerized intelligent tutoring system (ITS) for general chemistry. Three subject-matter area **experts** have been developed: (a) the fundamental and related concepts of atom, molecule, element, and compound, (b) inorganic nomenclature, and (c) oxidation number assignment. Students choose one of three modes after choosing a topic: Assessment, instruction, or practice. As students use CHEMPROF, their choices and responses are recorded in an archive file. The purpose of this study is to analyze the archival material in order to determine how students interact with an ITS. Archival material on first-semester general chemistry student usage has been collected for three semesters at the University of Wisconsin- Madison. We will include an analysis of the relationship between the time spent using CHEMPROF and student achievement. We have collected pre- and post-test data for concepts covered by CHEMPROF, and these data will also be analyzed.

19.12

THE EFFECTS OF HYPERMAPPING AND EMBEDDED COGNITIVE STRATEGIES ON BIOLOGY ACHIEVEMENT AND COMPLETION RATE OF HYPERMEDIA COURSEWARE

Gary J. Senn, The University of South Carolina at Aiken

For this study, the control group received the hypermedia courseware, Ecology and History of the Great Smoky Mountains National Park (Senn, 1992). Three other groups received the courseware with enhancements. The hypermapping group received the hypermapping enhancement, the suggestions group received the embedded cognitive strategies enhancement, and the combination group received both enhancements. Data were analyzed based upon student ability level (high, medium, and low). A posttest was used to determine biology achievement and a completion rate score was calculated to determine completion rate. There were no statistical differences in the ANOVA for treatment group membership versus the posttest. There was a significant difference between ability groups versus the posttest. The differences observed were between high and medium ability students,and high and low ability students. There was a significant difference between group membership and completion rate scores. This study supports that hypermapping is a useful tool for the hypermedia environment and that low ability students receive as much benefit from hypermedia presentations as medium ability students.

21.01

STUDENTS' CHANGING VIEWS TOWARD COMPUTERS-IMPLICATIONS FOR SCIENCE TEACHING AND SCIENCE TEACHER EDUCATION

William J. Boone, Indiana University-Bloomington

Small computers and peripherals are being used in science teaching and science teacher education in an ever increasing number of ways. One factor greatly effecting the degree to which classroom computers are used in science teaching are the attitudes of future science teachers toward computers. This study will present the results of tracking **computer attitudes** of over 170 future elementary science teachers during a two year period. Survey data indicate that these students did indeed become more positive toward the use of computers, however, survey items clearly indicate a wide range of views toward pre-college

21.01 BOONE CONTINUED

classroom computer usage. The results of evaluating these students' attitudes will be presented. Implications for science teaching and teacher education will introduced and observations solicited from the audience.

21.01

FACTORS THAT INFLUENCE THE USE OF MICROCOMPUTERS IN SCIENCE TEACHING IN RURAL SCHOOLS

Carol A. Borchers and M. Gail Shroyer, Kansas State University

The purpose of this study was 2-fold: (a) to test a national model for implementing microcomputer usage in science teaching in rural schools and (b) to research the organizational, community, professional, and procedural factors that influence microcomputer usage in rural science teaching. The national model consisted of a curriculum for preparing science teachers to use microcomputers and a trainer-of-trainers implementation model. Implementation of a model prepared for national dissemination in a rural environment required several adaptations. Factors identified as critical to successful implementation included congruency between teaching style and personal, organization, and community needs and priorities; pressure and support for microcomputers from administrators and community; access to hardware and software resources; collegiality among the participants, their district teams, and their fellow teachers; practicality of the project in terms of benefits outweighing costs; and isolation from other science teachers and the university. The results form the project also support the research from school change and staff development. The teachers implemented microcomputers into their teaching only after training, continuous support, and implementation assistance. This reiterates the position that staff development must be a continuous process of professional growth.

21.01

THE EFFECTIVENESS OF MICROCOMPUTER-BASED LABORATORIES IN MIDDLE LEVEL SCIENCE

Alan J. McCormack, San Diego State University

Microcomputer-based laboratories (MBL) use sensors or probes attached to microcomputers to measure and analyze data collected through laboratory investigations. This three year project trained 60 teachers to implement MBL as part of their regular school science programs. Evaluation of the approach followed a pre-test/post-test treatment group and control group design. Significant improvement in graphing skills and in experimental design capabilities resulted in treatment groups. Also, attitudes of students toward science and technology were positively impacted by the MBL experiences. Teachers involved in the project were found to successfully impact their colleagues by conduction MBL coaching and inservice sessions. Also, three laboratory manuals of MBL activities were produced by the project.

21.06

THE ROLE OF MICROCOMPUTERS IN THE EDUCATION OF GIFTED PRIMARY SCHOOL STUDENTS

Janice Batcheller, Worthington Community College, and D. Daryl Adams, Mankato State University

This study discusses how gifted primary learners interact cognitively with a computer during instruction and gains an understanding of ideas, feelings, motives and beliefs behind the use of computers by gifted learners. This study investigated whether gifted primary learners wished to: 1) control the computer (i.e. program it), 2) use the computer as a tool or 3) a combination of the two. This study used 84 primary students classified as gifted and utilized investigative qualitative methodology to collect data. These data were collected over a period of five months and employed listening to students as they experienced computer instruction, observing what they did, questioning them, and participating in computer classes. The students participating in this study showed the desire to use the computer as a tool to do work for them. Conclusions drawn from the data were that the majority of the gifted students liked to do

21.06 BATCHELLER CONTINUED

activities on the computer that they felt they were in control of (telling it what to do) and drawing graphs. Other data indicated that almost all gifted students truly enjoyed working with a computer and showed little or no apprehension towards using it and it was their favorite subject.

21.06

INTRODUCING COMPUTERS INTO HIGH SCHOOL SCIENCE CLASSROOMS: THE EFFECT ON HUMAN INTERACTIONS

Melissa Erickson and Linda S. Shore, Polymer Center Education Projects, Boston University

Computer simulations and **hands-on** activities are being developed that allow science students to explore the concept of fractals in nature. During the 1991-92 academic year these simulations were introduced into high school science classrooms. This study sought to find what effect the use of these materials had on the teachers and students in these classrooms. The researchers analyzed over 200 hours of classroom observation as well as formal and informal participant interviews to examine what, if any changes occurred for participants. There was found to be (1) an increase in one-on-one interactions between teachers and students, (2) more cooperative learning between students, (3) collaboration between science and math teachers using an interdisciplinary curriculum. Also examined were how changes in interactions between teachers and students affect student motivation and student learning.

21.06

INFLUENCE OF THE USE OF TELECOMMUNICATIONS UPON STUDENT MOTIVATION IN A SCIENCE CLASSROOM

Reuben Rubio and Joseph Krajcik, The University of Michigan, and Gary Canty, J. B. Edmonson Middle School

This study provides observations concerning the influence of the use of telecommunications on science students from a school district of traditional academic under-achievement and below-average socioeconomic status. The students were observed to show

21.06 RUBIO CONTINUED

persistence, intensity, and performance gain, and were continually motivated to utilize telecommunications on their own after the close of the intervention. Also, the ratio of computers to students was observed to play a role in the degree of increase .

22.06

MICROCOMPUTER SIMULATIONS IN SCIENCE CLASSROOMS: CASES OF PERCEIVED, OPERATIONAL AND EXPERIENTIAL CURRICULUM

David F. Jackson, University of Georgia
William E. Baird, Auburn University
Robert J. Beichner, North Carolina State University
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Robert D. Sherwood, Vanderbilt University
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When students work with microcomputer simulations in science classes, their actual learning experiences are often very different from those envisioned by their teachers. In turn, classroom procedures and task structures established by teachers are often in conflict with the original intentions of software designers. In an effort to identify the causes and possible remedies for these mismatches, this roundtable session follows an interactive format. Attendees, acting as a large cooperative group, use a commercially-available computer-based science simulation for 10-15 minutes. The author then lists selected data from classroom research on how students and teachers act and think when using the software in question. The other members of the roundtable group lead a discussion of specific software design changes which might improve the simulation and/or how teachers might better organize and execute lessons using such a simulation program.

24.06

THE SAFETY SIMULATOR-SCORING, RELIABILITY AND VALIDITY OF INTERACTIVE VIDEODISC-BASED ASSESSMENT OF SCIENCE TEACHERS.

Michal Lomask, Larry Jacobson, Laurin Hafner, and
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An experimental Interactive Video Disc (IVD) assessment program was developed to assess science teachers' knowledge of safety management of school lab activities. The IVD program contained two phases: 1) Panoramic view of the laboratory room, including safety equipment and storage of chemicals, 2) Simulation of a typical lab activity, performed by four high school students. Examinees were asked to identify and correct various safety errors that were simulated in the programs. Examinees' active verbal responses were recorded by the IVD system and transferred to video tapes which served as a basis of scoring. Reliability of scores was examined using inter rater percentage of agreement on scores and Generalizability analyses. Evidences for content, construct and criterion related validity of the IVD assessment scores as a measure of science teachers knowledge of safety regulations were assessed through studies of job relatedness, expert judgment and known groups performance comparisons. Hands-on presentation, in which science educators will serve as simulation developers, examinees, scorers and researchers, will be conducted to further learn about the construct validity of the new assessment.

27.1

THE STATE OF STS IMPLEMENTATION IN THE UNITED STATES AND ITS IMPLICATIONS

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National Center for Science Teaching and Learning

Science-Technology-Society (STS) Education has been one of the major foci of science education reform efforts and one of the most significant science curriculum developments in the United States. In order to determine accurately the status of stateimplemented (required/recommended/encouraged) STS education in science education and its surrogates in the US, a national telephone survey is being conducted as a part of a three phase study. (In addition to STS there are similar society-based science or technology education

27.1 BERLIN CONTINUED

programs which we call STS surrogates). The objective of this Phase I study is to determine the number of states that are currently implementing STS education in the United States, gather information about their implementation and to collect information about their curricula. Information from thirty states has been obtained to date. This data indicates that 8/30 states have required; 11/30 recommended; and 9/30 have encouraged STS education in their science curricula. One state has incorporated STS themes and one state has no STS education. Information obtained in this phase will be used in the subsequent phases: outcome studies and implementation model development.

27.01

INTERPERSONAL TEACHER BEHAVIOR AND SCHOOL CLIMATE

Darrell L. Fisher, University of Tasmania
Theo Wubbels and Mieke Brekelmans, University of Utrecht
Barry J. Fraser, Curtin University of Technology

This study brings together research on interpersonal teacher behavior with research on school-level climate. The sample consisted of 792 science and mathematics students and 46 teachers in 7 schools in Tasmania and Western Australia. Interpersonal teacher behavior was assessed with the 64-item Questionnaire on Teacher Interaction (QTI) which maps teacher behavior with a Proximity dimension (Cooperation-Opposition) and an Influence dimension (Dominance-Submission). School climate was assessed with the 56-item School Level Environment Questionnaire (SLEQ) which measures Student Support, Affiliation, Professional Interest, Staff Freedom, Participatory Decision Making, Innovation, Resource Adequacy, and Work Pressure. When the school mean was used as the unit of statistical analysis, three sets of significant relationship were found between interpersonal teacher behavior and school climate: Higher Work Pressure at the school level was associated with lower teacher Dominance and Cooperation in the classroom; teachers who participated more in decision making at the school level were perceived as less dominant and less cooperative in the classroom; and greater

27.01 FISHER CONTINUED

teacher Professional Interest at the school level was linked with less dominant and cooperative classroom behavior.

27.01

COMBINING QUALITATIVE AND QUANTITATIVE METHODS IN A STUDY OF INQUIRY-BASED COMPUTER LEARNING ENVIRONMENTS

Barry Fraser and Dorit Maor, Science and Mathematics Education Centre, Curtin University of Technology, Australia

Qualitative and quantitative research methods were employed to investigate students' development of inquiry skills and higher-level thinking skills during the use of a computerized scientific database. The use of a computerized database in inquiry-based science classrooms offers the potential to facilitate higher-level learning among students, a significant issue facing students and teachers today. An interpretive research methodology was employed to facilitate understanding of the multidimensionality of the learning processes in the classroom. Data were obtained from classroom observations, interviews with teachers and students, and students' entries in their workbooks. As well, two questionnaires were developed and used to evaluate the effectiveness of the program in terms of its impact upon the development of students' inquiry skills and upon the nature of the classroom learning environment. The explanatory study resulted in the generation of assertions about the learning and teaching processes in the classroom.

27.01

DEVELOPMENT OF A LEARNING ENVIRONMENT TYPOLOGY FOR SCIENCE LABORATORY CLASSES

Campbell J. McRobbie, Queensland University of Technology, and Barry J. Fraser, Curtin University of Technology

The aims of the study were to identify homogeneous types of science laboratory classrooms based upon measures of their psychosocial learning environments, and to investigate the extent to which different types of laboratory classes were associated differentially with cognitive and affective outcomes. The sample consisted of 1,594 grade

27.01 MCROBBIE CONTINUED

11 students in 92 chemistry classes in Australia who responded to the **Science Laboratory Environment Inventory** (which assesses Student Cohesiveness, Open-endedness, Integration, Rule Clarity, and Material Environment). Cluster analyses led to the identification of four clusters which were labelled (1) **positive** or **above average**, (2) **negative** or **below average**, (3) **open-ended integrated**, and (4) **closed-ended integrated**. The last two clusters both had high scores on Integration (the extent to which theory and laboratory work are integrated), but they differed markedly with respect to Open-endedness (the extent to which divergent activities are emphasized). The clusters were found to be associated differentially with outcome measures in that the **closed-ended integrated** cluster showed the highest scores on an inquiry skill measure, while the **below average** cluster consistently showed the lowest scores on a range of attitude dimensions.

27.01

THE IMPACT OF COMPUTER-ASSISTED LEARNING ON ACHIEVEMENT, ATTITUDES, AND CLASSROOM ENVIRONMENT IN SINGAPORE

George P. L Teh, Nanyang Technological University and
Barry J. Fraser, Curtin University of Technology

The aim of the study was to evaluate an innovation in computer assisted learning (CAL), involving the use of micro-PROLOG for teaching the topic of decision-making in Singapore schools, in terms of its impact upon (1) student achievement, (2) student attitudes, and (3) classroom environment. The study involved 12 teachers, each in a different randomly-chosen school, who taught one CAL and one control class. Altogether 671 students from the second year of high school were involved. A 30-item multiple choice achievement test and a 20-item semantic differential attitude measure were developed for the purposes of the study. A new 32-item classroom environment instrument was designed to assess four dimensions (**gender equity**, **investigation**, **innovation**, and **resource adequacy**) relevant to CAL classrooms. In contrast to past research, the use of CAL in this study led to massive impact in terms of achievement, attitudes, and classroom environment. For example, the effect size (in terms of differences

27.01 TEH CONTINUED

between CAL and control groups) was 3.5 standard deviations for achievement and 1.4 standard deviations for attitudes.

27.10

MEASURING CHILDREN'S PERCEPTIONS ABOUT TECHNOLOGY

Leonie J. Rennie, Curtin University of Technology
Tina Jarvis, University of Leicester

This paper reports the use of three instruments which comprise a comprehensive technique for determining children's perceptions about technology. The instruments are a questionnaire for middle school children, a quiz using pictures instead of written items for elementary school children and, for both age groups, a combined writing/drawing activity which complements the questionnaire or quiz. The instruments are designed to cater for children from a range of age levels, provide information helpful to teachers about children's perceptions of technology, and be suitable for use in research. A review of technology curriculum materials and previous research was used to structure the coding of the responses to the writing/ drawing activity and to develop the picture quiz. The questionnaire was developed in earlier work. The instruments were trialled in a total of 28 classes in Western Australian schools and construct validity established by examining the pattern of responses between pairs of instruments completed by the same children. Teachers found the process of administering the instruments illuminating and useful and they felt they learned much about children's ideas about technology from their participation in the process of developing the instruments.

28.05

SYMPOSIUM ON THE USES OF TECHNOLOGY WITH TEACHERS TO IMPROVE SCIENCE LEARNING IN THE CLASSROOM

Mary M. Atwater, David Jackson, John Wiggins, Patricia Simmons, and Mike Hale, The University of Georgia

This symposium focuses on three different microcomputer inservice experiences. Urban teachers are involved in two of the workshops, rural science teachers in the other. The research questions for the first

28.05 ATWATER CONTINUED

presentation include: How the beliefs and attitudes of urban science teachers who teach physical science changed in 12 weeks, how they used microcomputer-based laboratories in their classrooms, along with the kinds of assistance they requested, and how these teachers acted as change agents in their schools? An examination of teachers' attitudes and beliefs about their teaching and about their views toward the role of technology in their classrooms were elaborated in the second presentation. The third presentation provides information on the teachers' perceptions of the impact on their magnet curriculum. These perceptions included identifying problems under their control and not under their control and attempts at solving these problems when implementing technology in their classrooms.

END

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